This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

GB
54
.L5
1829

PHYSICAL GEOGRAPHY

BY [Lloyd, H. J.] for
THE SOCIETY
FOR THE
DIFFUSION OF USEFUL KNOWLEDGE

UNIVERSITY OF VIRGINIA LIBRARY
X004456585

LIBRARY OF USEFUL KNOWLEDGE.

SECOND EDITION.

PHYSICAL GEOGRAPHY.

PART I.

PUBLISHED UNDER THE SUPERINTENDENCE OF

THE SOCIETY
FOR THE
DIFFUSION OF USEFUL KNOWLEDGE.

COMMITTEE.

Chairman—H. BROUGHAM, Esq., F.R.S., M.P.

Right Hon. J. Abercrombie, M.P.
Wm. Allen, Esq., F.R.S.
Rt. Hon. Lord Althorp, M.P.
Rt. Hon. Lord Auckland.
Capt. F. Beaufort, R.N., F.R.S.
C. Bell, Esq., F.R.S. L. & E
T. W. Beaumont, Esq., M.P.
T. F. Buxton, Esq., M.P., F.R.S.
J. Carter, Esq., M.P.
R. Otway Cave, Esq., M.A., M.P.
William Crawford, Esq.
Frederick Daniell, Esq., F.R.S.
T. Denman, Esq.
Hon. G. Agar Ellis, M.A., M.P.
T. F. Ellis, Esq., M.A
I. L. Goldsmid, Esq., F.R.S.
Dr. Olinthus Gregory, LL.D.
Capt. Basil Hall, R.N., F.R.S. L. & E.
H. Hallam, Esq., F.R.S., M.A.
M. D. Hill, Esq.
Rowland Hill, Esq.
Leonard Horner, Esq., F.R.S.
David Jardine, Esq.
Henry B. Ker, Esq., F.R.S.
J. G. S. Lefevre, Esq. F.R.S.
Edward Lloyd, Esq., M.A.
James Loch, Esq., M.P., F.G.S.
Dr. Lushington, D.C.L., M.P.
Sir J. Mackintosh, M.P., F.R.S.
B. H. Malkin, Esq., M.A.
Rev. Ed. Maltby, D.D., F.R.S.
James Manning, Esq.
J. Marshall, Esq., M.P.
James Mill, Esq.
James Morrison, Esq.
Rt. Hon. Lord Nugent, M.P.
Sir H. Parnell, Bart., M.P.
Sir George Philips, Bart., M.P.
T. Spring Rice, Esq., M.P. F.A.S.
C. E. Rumbold, Esq., M.P.
Rt. Hon. Ld. John Russell, M.P.
Sir J. Scarlett, M.A., M.P.
J. Smith, Esq., M.P.
Wm. Sturch, Esq.
Rt. Hon. Lord Suffield.
Daniel Sykes, Esq., M.P.
Dr. A. T. Thomson, F.L.S.
William Eyton Tooke, Esq.
C. B. Wall, Esq. M.A. M.P.
H. Warburton, Esq., M.P., F.R.S.
H. Waymouth, Esq.
J. Whishaw, Esq. M.A. F.R.S.
John Wrottesley, Esq., M.A.

Treasurer—William Tooke, Esq., F.R.S., V. P. Soc. Arts.

Birmingham—T. Eyre Lee, Esq.
Jos. Parkes, Esq.
Bristol—J. Reynolds, Esq.
Derby—Joseph Strutt, Esq.
Dublin—Hon. Thos. Vesey.
Edinburgh—R. Greville, LL.D.
D. Ellis, Esq., F.R.S.
Fras. Jeffrey, Esq.
Prof. Napier, F.R.S.E.
W. Thomson, Esq.
Rev. A. Thomson, D.D.
Etruria—Jos. Wedgwood, Esq.
Exeter—J. Tyrrell, Esq.
Glasgow—D. Bannatyne, Esq.
Glasgow—Kirkman Finlay, Esq.
Robert Grahame, Esq.
Professor Mylne.
Alexander McGrigor, Esq.
Charles Macintosh, Esq.
Leeds—Benjamin Gott, Esq.
J. Marshall, Jun., Esq.
Lewes—John W. Woolgar, Esq.
Liverpool—Rev. W. Shepherd.
Dr. Trail.
J. Ashton Yates, Esq.
Maidenhead—Richard Goolden, Esq., F.L.S.
Manchester—G. W. Wood, Esq.
Newcastle—James Losh, Esq.
Rev. W. Turner.
Newport—Ab. Clarke, Esq.
T. Cooke, Jun., Esq.
R. G. Kirkpatrick, Esq.
Plymouth.—Geo. Harvey, Esq., F.R.S.
Portsmouth—E. Carter, Esq.
G. Grant, Esq.
D. Howard, Esq.
Rev. Dr. Inman, Naval College.
Sheffield—J. H. Abraham, Esq.

⁂ All Communications to the Society; Offers of Literary Assistance, with the Terms, &c., to be addressed to Mr. Coates, the Secretary, No. 29, Percy-street, Bedford-square; and, *if from the Country*, under cover to any of the Committee who may be in Parliament.

LONDON:
BALDWIN AND CRADOCK;
OLIVER AND BOYD, EDINBURGH; ROBERTSON AND ATKINSON,
GLASGOW; W. F. WAKEMAN, DUBLIN.
AND G. & C. CARVILL, NEW YORK.

Price Sixpence.
1828.
(23.) [ENTERED AT STATIONERS' HALL.] (*April 1.*)

TREATISES published to FEBRUARY 15, 1828.

THE OBJECTS, ADVANTAGES, AND PLEASURES OF SCIENCE.—Preliminary Treatise.
1. HYDROSTATICS.
2. HYDRAULICS.
3. PNEUMATICS.
4. HEAT—Part 1.
5. HEAT—Part 2.
6. MECHANICS—First Treatise, on Prime Movers.
7. ———— Second Treatise, on the Elements of Machinery.
8. ———— The same Subject—Part 2.
9. ANIMAL MECHANICS—First Treatise.
10. Familiar Account of LORD BACON'S NOVUM ORGANON SCIENTIARUM—Part 1.
11. MECHANICS—Third Treatise. On Friction.
12. OPTICS—Part 1.
13. OPTICAL INSTRUMENTS—Part 1.
14. VEGETABLE PHYSIOLOGY.
15. ELECTRICITY—Part 1.
16. MATHEMATICAL GEOGRAPHY.
17. ARITHMETIC AND ALGEBRA—Part 1.
18. NOVUM ORGANON SCIENTIARUM—Part 2.
19. OPTICS—Part 2.
20. LIFE OF CARDINAL WOLSEY.
21. OPTICAL INSTRUMENTS—Part 2.
22. ELECTRICITY—Part 2.

Printed by W. CLOWES, Stamford-street.

GD
54
.L5
1829
212293

PHYSICAL GEOGRAPHY.

PHYSICAL or *natural* geography might, if we regarded merely the strict meaning of the words, be limited to signify no more than a description of the principal features of the earth's surface; but it is usual, in treatises upon this branch of geography, to touch also upon the subject of climate and temperature,—to show how these, together with other natural causes, affect the condition of the human race—and to advert, in a general manner, to the animals and productions of the globe.

Geographical terms explained.

In looking over a map of the world, it is seen at once that the surface consists of various spaces of *land*, surrounded by an extensive field of water called the *sea* or *ocean*. Of these spaces of land, two are of vast extent, and on this account are termed *continents* *, (derived from a Latin word signifying, *holding together* or *connexion*). The larger of these continents includes the three divisions of Europe, Asia, and Africa, and is distinguished by the title of the *old continent*, from its having, till the discovery of America, by Columbus in the year 1492, been the only one with the existence of which Europeans were acquainted. The other, which includes North and South America, is named the *new continent*. The smaller portions of land which are scattered over the ocean are denominated *islands*. A great many islands lying together are called an *archipelago*.

In many places the land and the ocean run one into the other. When the ocean penetrates into a continent by a narrow passage, and then spreads again into a large expanse, this inland portion of the ocean is usually termed a *sea*. If the extent of such an inland sea be less, or the passage by which it communicates with the main ocean larger, it is called a *gulf* or *bay*. An inland body of water not connected with the ocean or any of its branches, is called a *lake*. A narrow passage of water leading from one sea to another is called a *strait;* a narrow neck of land lying between two seas, and connecting two masses of land greater than itself, is called an *isthmus*. When, on the other hand, a part of a continent runs out into the sea, and is joined to the main land by only a small portion of its circumference, it is named a *peninsula*, (that is, an *almost island*). If the projections of land reach but a little way into the sea, they are called *capes*, *headlands*, or *promontories*.

General View of the Globe as consisting of Land and Sea.

There is, in fact, only one continuous fluid surrounding the land, all the gulfs and inland seas being branches † of this universal ocean; but for the sake of convenience different parts of it have distinct names given to them. The following table, exhibiting the principal seas into which the ocean has been divided, will be clearly understood upon referring to the map of the world on Mercator's projection:—

---

* New Holland, by some geographers, is regarded as a third continent; but if we consider how much smaller it is than either of the two vast tracts above-mentioned, it will appear correct rather to assign it the first station among the *islands* of the globe. New Holland and the islands around it are, however, not unworthy of being classed as the fifth grand division of the world. English geographers have named them *Australia* (that is, *Southern lands*.)

† The Caspian *Sea*, as it is generally termed, forms no exception to this remark, because it is in fact only an immense lake.

GIFT
JAN 10 '36
BINDING
MAR 22 '37

I. The great *South Eastern* basin, the waters of which cover nearly half the globe. It includes

1. The *Antarctic Ocean*, which is comprised within the Antarctic circle, that is, between the parallel of 66° 32′ of southern latitude and the South Pole.

2. The *Southern Ocean*, the boundary of which on one side is the Antarctic circle, on the other a line drawn from Cape Horn to the Cape of Good Hope, thence to Van Diemen's Land, and again by the south of New Zealand to Cape Horn. This line forms the southern boundary of Nos. 3 and 4.

3. The *Indian Ocean*, lying between Africa on the west, and the peninsula of Malaya with the islands of Sumatra, Java, &c., and New Holland, on the east, and bounded by Persia, and Hindustan on the north. The Red Sea, or Arabian Gulf, the Persian Gulf, and the Bay of Bengal are all parts of this ocean.

4. The *Pacific Ocean*, divided by the equator into *North* and *South*, and inclosed between America on the east, and New Holland, the islands of Java and Sumatra, and the continent of Asia, on the west. On the north it terminates at Behring's strait. The seas of China, Japan, Okhotsk, &c. form parts of this ocean.

II. The *Western* basin, forming a channel between the old and new continents.

1. The *Atlantic Ocean*, commencing in the south from a line drawn from Cape Horn to the Cape of Good Hope, and terminated on the north by the Arctic circle. It is divided into *North* and *South* by the equator, and its branches are the Mediterranean, the North Sea or German Ocean, the Baltic, Baffin's Bay, Hudson's Bay, the Gulf of Mexico and the Caribbean Sea.

2. The *Arctic Ocean*, surrounding the North Pole, and bounded by the Arctic circle and the northern shores of the two continents. The White Sea, the sea of Kara, and the Gulf of Obe are parts of it.

The Ocean is spread over nearly seven-tenths of the globe; but it is remarkable how unequally the land and water are distributed. If we look at a map of the world projected upon the horizon of London, in which map, consequently, London forms the centre of the one hemisphere and the antipodes* to London, the centre of the other; the first hemisphere, it will be seen, contains a very large proportion of the whole of the land, while the second, if we except New Holland and the extremity of South America, from the twenty-ninth degree of south latitude, consists almost entirely of water. The distribution of water and land is still very unequal, if we compare only the northern and southern hemispheres, that is, the two equal parts into which the globe is divided by the equator. The following calculation will plainly exhibit this fact:

Considering the whole space included in the northern part of the torrid zone, as equal to 1, the proportion of land is	0.297
On the same supposition, the proportion of land in the northern temperate zone is	0.559
And in the northern icy zone	0.400
In the southern part of the torrid zone, the portion of land is . .	0.312
In the southern temperate zone	0.075
In the southern icy zone (supposed)	none.

In other words, if the quantity of land in the northern hemisphere be represented by 16, the quantity in the southern will be scarcely equal to 5.

About the middle of the last century it was asserted that a great continent must exist towards the south pole, in order to counterbalance the mass of land in the northern hemisphere; but by the voyages of Cook and others, it has been proved that the high southern latitudes contain only a few islands.—The absence of a continent near the south pole does not of itself prove that there is less land there than in the north, since it is possible that the land in general may be only rather more depressed in the south, the necessary result of which would be, that the ocean would spread itself more extensively over the surface of the earth in that quarter.

---

* A small island lying to the south-east of New Zealand, and called Antipodes island, is very nearly the antipodes to London.

On the Figure, &c., of the Continents.

The general direction of the land in the two continents is entirely different. In America, it is from pole to pole; in the old world, it is from south-west to north-east, and, if we keep Africa out of view, it is almost parallel to the equator. The longest straight line that can be drawn on the old continent commences on the western coast of Africa, from about Cape Verd, and extends to Behring's strait in the north-east of Asia. It is about 11,000 miles in length. A similar line, traced along the new continent, passes from the strait of Terra del Fuego, to the northern shore of North America, and is nearly 9000 miles long. In both continents the direction of the large peninsulas is similar, almost all of them running towards the south. This is the case with South America, California, Florida, Alaska, and Greenland in the New World, and in the Old with Scandinavia, Spain, Italy, Greece, Africa, Arabia, Hindustan, Malaya, Cambodia, Corea, and Kamtchatka. The only exceptions to this remark, are the peninsula of Yucatan in Mexico, and that of Jutland in the north-west of Europe. Both of these are directed towards the north; but they consist of plains and alluvial land, whereas the other peninsulas are more or less of a mountainous character. There is a further resemblance between the two continents, from each being divided into two parts by an isthmus *; but in the character of their outlines they differ very much: for while the coast of the Old World (independent of Africa) is broken equally on all sides by gulfs, bays, and inland seas, the New World has a series of openings on its eastern shore only. Of its western side, the only inlet of any magnitude is the gulf of California.

On Mountains.

Mountains are the most considerable elevations of the surface of the earth. They may be divided into two classes: those of which the chains are the most lofty, rugged, and extensive, such as the Andes, the mountains of central Asia, the Alps, &c., and those of a less majestic character, which frequently form branches as it were of the first class. The Apennines, which traverse the whole length of Italy, and the Carpathian range, which in a great measure surrounds Hungary, are of this second description. All elevations which are either of such an inferior kind, or take place in such a gradual manner as not to come within these two classes, are termed *hills* or *slopes*.

Mountains most commonly are so near to each other, and are disposed in such a manner, as to give the idea of *chains*. A chain may be defined as a series of mountains, the bases of which are continuous; but it is well to observe that the name is sometimes applied to collections of hills without much regard to its strict meaning. Sometimes chains run out from a common centre: those which proceed from the high table-land of central Asia, may be considered as an example; at others the centre mass itself is a lofty chain to which secondary chains are attached: such are the Alps. In some instances there are irregular groups of several chains, among which none can be ranked as the principal: of this the mountains in Asia Minor and Persia are examples. The most remarkable, however, are long connected chains, which, like the Andes †, continue for several thousand miles, nearly in one direction, having on both sides inferior ranges, but sending off hardly any secondary chains. These appear to be of the highest antiquity.

Some mountains are completely insulated, that is, are quite remote from any chain or group. Volcanoes are more particularly of this kind.

The character of mountains would seem to depend upon the sort of rock of which they are composed. Granite, when exposed, forms lofty and rugged elevations; gneiss is much less precipitous, and slate commonly not at all so. In this respect there is a remarkable difference, which Humboldt has noticed, between the Old and New Continents. In the former the highest points of the Alps consist of granite; but in America, granite is not found higher than 11,000 or 12,000 feet above the level of the sea, and the newest flœtz trap or whinstone, which in Europe appears only in low mountains, or at the foot of those of great magnitude, covers the tops of the Andes. Chimborazo and Antisana are crowned with vast walls of porphyry; and basalt, which in our continent has not been observed higher than 4300 feet, is on the very summit of Pichincha. Other secondary formations, among which may be mentioned limestone, are also found at greater heights in the New than in the Old world.

---

* The isthmus of Suez is composed of sand; that of Panama or Darien consists of stupendous rocks.

† The name of *Andes* is given only to the chain on the west coast of *South America*; the continuation of that chain in North America has other titles; but they evidently form one grand whole.

With respect to their declivities, it is observed that most of the principal mountains have one of their sides very steep, and the other of a gradual slope. The Alps, for instance, have a much more abrupt descent on the side of Italy than on that of Switzerland; the Pyrenees are steeper towards the south than the north, while the chain of Asturias, which branches westward from the Pyrenees, is just the reverse. Mount Taurus, in the part where it approaches the Mediterranean and the Dardanelles, is abrupt on the south, but in Armenia it has a rapid descent northward. The mountains of Scandinavia are steeper towards the west and north-west, than the south and east; and the Ghauts in Hindustan are in like manner precipitous on the west, and sloping in the opposite direction. With all these chains, therefore, and indeed with most of the chains of the globe, their steepest side is found to be that which approaches most nearly to the sea, and consequently their inclination is most gradual towards the interior of the country in which they are situated.

Mountains in their course commonly make numerous curves and angles; but in most cases the *general direction* of the principal chains appears almost, if not entirely, to correspond with the greatest length of the continents to which they belong. The Andes in South and the Stony Mountains in North America exemplify this remark; as do also the chains which, with little interruption, pass from the north-eastern point of Asia to the south-west coast of Portugal, and to the western side of Africa. The secondary chains, in the same manner, frequently follow the greatest length of the large peninsulas. This is the case with the Apennines in Italy, the Dovrefield in Scandinavia, the Ghauts in Hindustan, &c.

In order to obtain a connected view of the loftiest and most extensive system of mountains upon the globe, we must suppose ourselves placed in New Holland with our face turned towards the north; America will then be on the right, Asia and Africa on the left. From Cape Horn to Behring's strait along the western coast of America, there is an almost uninterrupted range of the highest mountains; from Behring's strait again succeeds an enormous line passing in a south-westerly direction through Asia, leaving China and Hindustan to the south, somewhat interrupted as it approaches Africa, but still to be looked upon as continuing its course in the mountains of Persia and Arabia Felix. From Cape Gardafui in Africa to the Cape of Good Hope, there appears to be a chain which completes the view. The series of mountains which we have thus followed, is in the form of an immense irregular curve, which comprises within it, the Pacific and Indian Oceans, with their innumerable islands, besides a portion of Asia, including China, the Birman dominions, and the Indian peninsula. It presents a steep face towards these oceans, while, on the other side, the land very generally slopes towards the Atlantic and Arctic Oceans.

The following is a table of the height of some of the principal mountains of the globe, reckoning from the level of the sea. The elevations of those in Asia and Africa are far from having been ascertained with accuracy. Some recent measurements make the highest summits of the Himalayan range as much as 28,000 feet; but, though these calculations seem very doubtful, it is not unlikely they are at least 25,000 feet high.

Europe.

		Feet.
Mont Blanc †	The Alps	15,668
Mont Rosa		15,527
Ortler Spitze in the Tyrol		15,430
Aiguille d'Argenture		13,389
Eiger		13,170
Jungfrauhorn		13,730
Shreckhorn		13,310
Wetterhorn		12,500
Pass of Great St. Bernard		7,968
Ditto of Mont Cenis		6,778
Ditto of the Simplon		6,580
Nethou †	Pyrenees	11,427
Perdu		11,275
Canigou		9,145
Monte Corno † (Apennines)		9,523
Lomnitz † (Carpathian)		7,962
Sneehaetta † (Dovrefield in Norway)		8,122
Mulhaçen † (Sierra Nevada of Grenada in Spain)		11,678
Mont Mezin † (Cevennes in the south-east of France)		6,567
Puy de Sancy † (Mountains of Auvergne in France)		6,215
Etna * in Sicily		10,870
Vesuvius * near Naples		3,932

		Feet.
Asia.		
Dhawalagiri	Himalaya	28,077
Jewahir		25,747
Mowna Roa (Sandwich Is.)		15,988
Ophir (Sumatra)		13,840
Egmont (New Zealand)		11,430
Italitzkoi (Altaian chain)		10,735
Ararat (Armenia)		9,600
Olympus (Anatolia)		6,500
Awatsha * (Kamtchatka)		9,600
Lebanon (Palestine)		9,600
Africa.		
Geesh	Abyssinia	15,000
Amid Amid		13,000
Lamalmon		11,200
Chain of Atlas †		11,980
Peak of Teneriffe *		12,180
America.		
Chimborazo †	Andes	21,425
Cayambe		19,633
Antisana *		19,136
Cotopaxi *		18,867
Yliniza		17,376
Tolima		18,324
Cotocache		16,436
Pichincha *		15,931
Farm of Antisana (inhabited)		13,437
City of Quito		9,542
Popocatepetl *	Mexico	17,720
Iztaccihuatl		15,705
Coffer of Perote		13,275
Lake of Toluca		12,195
Silla de Caraccas (Venezuela)		8,633
Duida (Mountains of Parime)		8,314
Itacolumi (Brazil)		5,756
Mount Washington † (Alleghanies)		6,650
Blue Mountains (Jamaica)		7,278
Mount St. Elias		17,863
Mount Fairweather		14,736

(NOTE) Those marked * are volcanoes. And † are the highest points of the range to which they belong.

On Volcanoes.

The term *Volcano* (derived from VULCANUS, the name which the Romans gave to their imaginary god of fire) is applied to those mountains which send forth from their summits or sides, flame, smoke, ashes, and streams of melted matter called lava. Upon ascending to the top of a mountain of this kind, there is found to be an immense and deep hollow, which is denominated the *crater* or *cup*. From most of the volcanoes which are not extinct, there is a smoke more or less frequently arising; but the *eruptions*, which are discharges of stones, ashes, lava, &c., accompanied with lofty columns of fire, violent explosions and concussions of the earth, happen at irregular and sometimes very long intervals. It seems to be a very general rule that the greater the mass and the elevation of the mountain, the less frequent and more tremendous are the eruptions. Stromboli, the small volcano on one of the Lipari islands, is almost always burning; Vesuvius has more frequent eruptions than Etna; while the immense summits of the Andes, Cotopaxi, and Tunguragua have an eruption hardly once in a century. The volcanoes of America, besides the common lava and rocks, &c., cast out scorified clay, carbon, sulphur, and water *, accompanied, in some instances, by fishes.

The eruption the most astonishing, perhaps, of any upon record is that which, in April 1815, issued from the Tomboro mountain in Sumbawa, one of the islands of the Indian Archipelago (see Notes to chap. i. of *Raffles' History of Java*); and we mention it, in order to give an idea of the violence which sometimes characterises volcanic agency. The tremulous motions which the ground underwent, during this eruption, were felt throughout a circular space of nearly 2000 miles in diameter, and the report of the explosions was heard over an equally extensive area. Within its more immediate range, embracing a space of 300 miles around it, it excited the greatest alarm. On Java, at the distance of 300 miles, the sky was overcast at midday with clouds of ashes, the showers of which covered every thing to the depth of several inches; and explosions were heard, at intervals, like the report of artillery or the noise of distant thunder. On Sumbawa itself thousands of individuals were destroyed by the fury of the eruption.

What may be termed *mud volcanoes*, from their having eruptions of mud only, are another curious phenomenon. One of these, which is situated towards the middle of the island of Java, in a plain abounding with salt springs, is thus described in the 9th volume of the *Batavian Transactions:* "On approaching it from a distance, it is first discovered by a large volume of smoke, rising and disappearing at intervals of a few seconds, resembling the vapours arising from a violent surf: a dull noise is heard, like that of distant thunder. Having advanced so near, that the vision was no longer impeded by the smoke, a large hemispherical mass was observed, consisting of black earth mixed with water, about 16 feet in diameter, rising to the height of

---

* Etna has been known to eject Water.

20 or 30 feet in a perfectly regular manner, and, as it were, pushed up by a force beneath—which suddenly exploded with a dull noise, and scattered about a volume of black mud in every direction. After an interval of two or three, or sometimes four or five, seconds, the hemispherical body of mud or earth rose and exploded again. In the same manner this volcanic ebullition goes on without interruption. The spot where it occurs is nearly circular and perfectly level; it is covered only with the earthy particles, impregnated with salt water, which are thrown up from below: the circumference may be estimated at about half a mile. A strong, pungent, sulphureous smell is perceived on standing near the explosion, and the mud recently thrown up is warmer than the surrounding atmosphere. During the rainy season these explosions are more violent."

The mountain of *Maccaluba* in Sicily, and some hills at the town of Taman in the Crimea, are also distinguished by eruptions of mud.

It is remarkable, that in the Old Continent, the principal chains of mountains contain no volcanoes, and that islands, and the extremities of peninsulas, are alone the seats of these convulsions; while in the New World, the immense range which runs along the shore of the Pacific Ocean possesses more volcanoes than are to be met with in the whole of the Old Continent and its adjacent islands. Professor Jameson has given the following estimate of the number of volcanoes:—

Continent of Europe	1[*]
Islands of ditto	12
Continent of Asia	8[†]
Islands of ditto	58
Continent of America	97
Islands of ditto	19

No volcano has yet been discovered on the continent of Africa, but most of its groups of islands are distinguished by them.

A line drawn round the Great Pacific Ocean, so as to include the long range of mountains on the west of America, the Asiatic peninsula of Kamtchatka, and the islands of Sumatra and Java, will have within it, by far the grandest and most extensive *volcanic system* on the globe. From Terra del Fuego, *(the lana of fire,)* to the peninsula of Alaska, a complete series of volcanoes may be traced. The Aleutian islands, which stretch from that peninsula to the opposite peninsula of Kamtchatka, possess several. On Kamtchatka, there are some of great violence. The islands of Japan and Formosa have several, and beginning with Sumatra and Java, they are scattered all over that immense Archipelago which forms so remarkable a feature of the Pacific Ocean.

In the Indian Ocean, the Islands of St. Paul, Amsterdam, and Bourbon, have volcanoes in action. The most formidable volcanoes of the Mediterranean are Etna in Sicily, and Vesuvius upon the coast of Naples. Between these two mountains are the Lipari islands, all of volcanic character. The Atlantic Ocean contains several groups of this kind; Iceland has suffered frequently from the terrific eruptions of its volcanoes; the Azores and the Canaries, and some of the West India islands, also experience the effects of subterranean fire.

In some places, parts of the land which are covered by the waters of the ocean are the seats of volcanoes; and it has sometimes happened, that new islands have been formed during *submarine* eruptions. A recent instance of this kind occurred in 1811, in the neighbourhood of St. Michael, one of the Azores, the small group which lies about 800 miles to the west of Portugal. This new island has since disappeared. It is probable, that some clusters of islands (among which are the Azores, just mentioned, and the Lipari islands north of Sicily) owe their origin to the breaking out of submarine volcanoes.

Several mountains bear evident marks of having at some very distant period been the outlets of fires; and on this account, they are called *extinct* volcanoes.

On Valleys and Plains.

Valleys are the spaces lying between opposite ridges of mountains or of hills, and their lowest part is commonly the bed of some torrent or river, which originates in the higher grounds. Those between high mountains are in general narrow and long, resembling large clefts or fissures. In some of these valleys, among the Alps and Pyrenees, it has been observed, that the nooks or angles on each side correspond with such exactness to projections on the opposite side, that if it were possible to exert a force sufficient to bring their sides together, they would fit into each other so closely, that no trace of the opening would remain. Such valleys as these would seem to have been formed by some convulsion of nature. The narrow openings which are the entrance to the high valleys, are called *passes* or *defiles*, and these are often of the most gloomy and terrific aspect. Valleys, which are upon a lower level than the class just mentioned, are wider and more soft in their features, and gradually lose themselves in the plains. *Plains* are likewise of two kinds. Those which are extensive, but very elevated, come under the denomination of *table land*. There are several plains of this sort; but the most remarkable are those among the Andes*, those of Mexico, and the immense plains in central Asia, to the north and north-east of Hindustan. The great Himalayan and Altaian chains form the ramparts, as it were, of this extensive and desolate table-land, a large proportion of which is the desert of Gobi † or Shamo. The *low plains*, from the nature of their soil, seem formerly to have been covered by the sea. The large plain, to the south of the Baltic, is one out of several instances of this character.

---

[*] Vesuvius.

[†] On the peninsula of Kamtchatka.

On Islands.

Large islands exhibit, on a smaller scale, the same appearances as the continents: upon them, therefore, it is unnecessary to make any observations, but with respect to smaller islands, the circumstance of their commonly being in groups or chains, deserves attention. Some are banks of sand, just raised above the surface of the water. Many islands, especially those in the South Sea, owe their origin to the marine insects which produce the coral. Some groups, as has already been observed, appear to have been raised up by the action of submarine volcanoes. Since the bed of the ocean possesses as much variety of surface as the land, there is no doubt that groups or chains of islands very near to each other, and which have not been raised up by such processes as those just alluded to, are only the different summits of an extensive submarine system of mountains; and when these collections of islands lie close to mountains on shore, they may be considered as a continuation of the latter. The Aleutian isles, which run in a curve south of Behring's strait, connect in this manner the mountains of the New with those of the Old World. In some cases, where a chain of islands extends from one part of the shore of a main land to another, it would appear as if, at a remote period, the sea had overwhelmed a portion of the main land, leaving those spaces uncovered which now form the islands. This seems still more probable if the water on the land side of the chain be not very deep, or if the islands are of a lofty and mountainous character. It has been supposed that, among others, the West India islands and the Archipelago between New Holland and the opposite coast of Asia, were rendered insular by an incursion of the ocean having detached them from the continents to which (if this supposition be just) they formerly belonged.

On Springs and Rivers.

The origin of the numerous springs that break forth from beneath the earth's surface cannot be referred to one exclusive cause. The internal reservoirs by which they are supplied are, in many cases, derived from the water which the earth absorbs from rains and melted snow; from these reservoirs, wherever there is uneven or mountainous ground, the water flows out by minute fissures in the sides of the hills. But when we see springs rising up in plains, it is evident that they must have *ascended*, that is, travelled in a direction *contrary* to that produced by the force of gravity, in order to reach the surface. This, no doubt, is sometimes to be attributed to water flowing under ground from distant elevations, and to the natural tendency of a liquid to find its level. But the rising up of springs, in plains, cannot always be accounted for in this manner; and it has, therefore, been supposed, that the earth contains capillary tubes, the effect of which, in attracting liquids upwards, is explained in Chapter VIII., of the treatise upon Hydrostatics. It is also evident that such springs as suffer no diminution even from the longest continued dry weather, must be derived from a source quite independent of rains, and other external means of supply. They must, therefore, proceed from some vast body of water within the earth; and it has, with apparent reason, been concluded, that many springs arise from the ocean filtering through the pores of the earth, the salt particles being lost in the passage.

---

* The plains of Quito are 12,000 feet above the level of the sea.

† This word, which is usually but incorrectly written *Kobi* or *Cobi*, signifies a *naked desert*.

Springs, which have their waters combined with mineral substances, and are, from that circumstance, called *mineral*, are very numerous, and of various kinds. *Warm* and *hot* springs are also common, especially in volcanic countries, where they are sometimes distinguished by violent ebullitions. Iceland is noted for these curious phenomena: its celebrated boiling fountain, the great *Geyser*, frequently throws out its contents to the height of more than a hundred feet, sometimes to twice that elevation.

Rivers are to be traced to springs, or to the gradual meltings of the ice and snow which perpetually cover the summits of all the most elevated ranges of mountains upon the globe. The union of various springs, or of these meltings, forms rivulets: these last follow the declivity of the ground, and commonly fall, at different stages, into one great channel, called a river, which, at last, discharges its waters into the sea, or some great inland lake. The declivities along which descend the various streams that flow into one particular river are called its *basin*, a term, therefore, which includes the whole extent of country from which the waters of the river are drawn. As mountainous regions abound in springs, we find that most rivers, more especially those of the first class, commence from a chain of mountains: each side of a chain also has its springs, and the rivers which originate on one side flow in the opposite direction to those which rise on the other. As it is the property of water to follow the most rapid descent that comes in its way, the courses of streams naturally point out the various declivities of the earth's surface, and the line from which large rivers flow in contrary directions will generally mark out the most elevated parts of the earth. In European Russia, where the rivers are very extensive, there is, however, a singular exception to this rule, the line which separates the sources of those rivers being very little above the level of the Baltic or of the Black sea. It has been observed by some writers, that the extent of a river is in proportion to the height of the range of mountains from which it descends. This is, in a certain degree, true, because the greater the bulk of the mountains, the more numerous the springs and torrents which they furnish; but the relation between the extent of a river and the surface of its basin is much closer and more invariable. Even this is not sufficiently comprehensive, for it is evident that the size of a river depends upon three circumstances—the surface of its basin—the abundance or otherwise of that surface in springs—and the degree of humidity possessed by the climate of the region from which it draws its supplies. As many springs, however, are formed by the rains, the second of these circumstances will, in some measure, vary with the last. By an attention to these remarks, the causes of the great size of the South American rivers will be apparent. The peculiar position of the Andes with respect to the plain of that continent,—the fact that by very far the largest proportion of its running waters are drained off in one general direction (towards the Atlantic)—the multiplicity of streams that intersect the country,—and the humidity of the climate, all contribute to that result. The Andes being placed so near the coast of the Pacific, the rivers which flow from them into that ocean are small; while those which flow on the other side, having such an immense space to traverse, are swelled into a most majestic volume before they reach the Atlantic. The physical circumstances of the old continent are unfavourable to the accumulation of such vast bodies of water as the rivers of South America. Europe is not of sufficient extent; Africa is oppressed by a scorching climate, and abounds in sandy deserts; in Asia the atmosphere generally is not so moist, while the more central position for the most part of the great mountainous range of that continent, and the existence of capacious inland lakes*, which are the final receptacles of the streams that fall into them, are the causes why the waters are more equally drained off in different directions than in the New World.

When water, by following a descent, has once received an impulse, the pressure of the particles behind upon those before will be sufficient to keep the stream in motion, even when there is no longer a declivity in the ground. The only effect is, that in passing along a level, the course of the stream becomes gradually slower, an effect which may be perceived, more or less, in all running waters that originate in mountainous or hilly tracts, and afterwards traverse the plains. The declivity of many great rivers is much less than might at first be supposed. The Maranon or Amazons has a descent of only $10\frac{1}{2}$ feet in 200 leagues of its course, that is, $\frac{1}{27}$th part of an inch for every 1000 feet of that distance. The Loire, in France, between Pouilly and Briare, falls one foot in 7,500, but between Briare and Orleans, only one foot in 13,596. Even the rapid Rhine has not a descent of more than four feet in a mile, between Schaffhausen and Strasburg, and of two feet between the latter place and Schenckenschantz. When rivers proceed through mountainous and rugged country, they frequently fall over precipices and form *cataracts*, in some cases several hundred feet in depth. The most celebrated falls in the world are those of the Niagara, in North America.

---

* The Caspian Sea and Lake Aral.

In the tropical regions most of the rivers are subject to periodical overflowings of their banks, in consequence of the rains which annually fall in such abundance in those countries during the wet season. The overflow of the Nile was considered by the ancients, who were ignorant of its cause, as one of the greatest mysteries of nature, because in Egypt, where the overflow takes place, no rain ever falls. The apparent mystery is easily explained, by the circumstance of the rains descending upon the mountains in the interior of Africa where the Nile rises. The consequent accumulation of the waters among the high grounds gradually swells the river along its whole extent, and in about two months from the commencement of the rains, occasions those yearly inundations, without which, Egypt would be no better than a desert.

The disappearance of some rivers for a certain distance under ground is accounted for with equal facility. When a river is impeded in its course by a bank of solid rock, and finds beneath it a bed of a softer soil, the waters wear away the latter, and thus make for themselves a subterraneous passage. In this way are explained the *sinking of the Rhone*, between Seyssel, and l'Ecluse, and the formation, in Virginia, of the magnificent rock bridge which overhangs the course of the Cedar creek. In Spain the phenomenon exhibited by the Guadiana, which has its waters dispersed in sandy and marshy grounds, whence they afterwards emerge in greater abundance, is to be referred to the absorbing power of the soil.

Rivers, in their junction with the sea, present several appearances worthy of notice. The opposition which takes place between the tide and their own currents occasions, in many instances, the collection at their mouths of banks of sand or mud, called *bars*, on account of the obstruction which they offer to navigation. Some streams rush with such force into the sea, that it is possible, for some distance, to distinguish their waters from those of the sea. The shock arising from the collision of the current of the majestic Amazons with the tide of the Atlantic is of the most tremendous description. Many of the largest rivers mingle with the sea by means of a single outlet, while others, for instance the Nile, the Ganges, the Volga, the Rhine, and the Orinoco, before their termination, divide into several branches*. This circumstance will depend upon the nature of the soil of the country through which a river runs; but it also frequently results from the velocity of the stream being so much diminished in its latter stage, that even a slight obstacle in the ground has power to change its course, and a number of channels are thus produced. Another cause may be assigned for the division into branches of those rivers, which, in tropical countries, periodically inundate the plains; the superfluous waters which, at those periods, spread over the country, find various outlets, which are afterwards rendered permanent by the deepening of the channels by each successive flood. In some of the sandy plains of the torrid zone the rivers divide into branches, and, from the nature of the soil and the heat of the climate, they are absorbed and evaporated, and thus never reach the sea.

On Lakes.

Lakes may be classed into *four* distinct kinds. The *first class* includes those which have no outlet, and which do not receive any running water. They are usually very small; some appear to be the craters of extinct volcanoes filled with water. The *second class* are those which have an outlet, but which receive no running water. They have been formed by springs flowing into some large hollow: upon the water rising up to the top of the hollow, it would, of course, run over the lowest part of the edge, and thus find an outlet, and these outlets are, in some cases, the beginnings of very large rivers. As these lakes receive no stream, they must necessarily, in most cases, be in elevated situations. There is one of this kind on Monte Rotondo in Corsica, which is 9000 feet above the level of the sea.

---

* The triangular space formed by a river pouring itself into the sea by various mouths, is called a *Delta*, from its resemblance to the shape of the fourth letter (Δ) of the Greek alphabet.

The *third class*, which embraces all those which both receive and discharge streams of water, is much more numerous than any. Though they are the receptacles of many streams from the neighbouring country, they usually have each but one outlet, which often takes its name from the principal river that runs into the lake. The largest lakes of this class are the immense bodies of water in North America, between Canada and the United States. There are five, (Superior, Michigan, Huron, Erie, and Ontario,) almost like seas in extent, connected together, and their purity is maintained by means of the continual flow of water which is kept up from one to another. Their final outlet to the Atlantic Ocean is the great river St. Laurence. Lake Baikal, in Asiatic Russia, is also remarkable for its size; it sends forth a large stream which joins the Yenisei.

The *fourth class* of lakes comprises a very small number, but they are the most singular in their character of all. They are those which receive streams of water and often great rivers, but have no visible outlet whatever. The most celebrated are the Caspian Sea and Lake Aral, both situated in the west of Asia. The Caspian is between 600 and 700 miles long, and, in one part, between 300 and 400 miles in width; it receives some very large rivers, the chief of which are the Volga, the Ural or Yaik, and the Kur; yet, notwithstanding the plentiful supply of water which is constantly being poured into it, it not only exhibits no increase, but there is strong reason to believe, from the appearances round its shores, that its surface is now much lower than it was at a former period *. Many conjectures have been offered to account for this apparent anomaly; but, after all, the process of evaporation seems quite sufficient to explain it, especially when we consider the extensiveness of the surface which this inland sea (as it is termed) presents, to be acted upon by the atmosphere. Lake Aral is much smaller than the Caspian, but possesses the same peculiarities, and, from the character of the isthmus which separates them, it is supposed that they formerly composed one body of water. They are both *salt* lakes, and are distinguished by marine productions; from these circumstances it has been conjectured that they must, at a very remote period, have been connected with the Black Sea. If such a connection ever existed, the separation may have been occasioned by an accumulation of alluvial soil, brought down by the rivers Don and Volga.

The phenomena presented by some lakes are of a very curious kind. Several of these bodies of water are *periodical* in their appearance. In tropical countries, owing to the violent rains and the overflowing of the rivers, spaces of several hundred miles are often covered with water. South America has large lakes which are annually formed in this manner, and are again dried up by the powerful evaporation of an equatorial climate. Some lakes there are which periodically appear and disappear, owing (it is thought) to their invisible connexion with some subterranean reservoir, by the alternate increase and diminution of which they are necessarily influenced. Lake Cirknitz in Illyria is of this description. The motions and agitations which certain of these bodies of water experience are more difficult to explain. Some of them appear agitated by the escape of subterraneous gases, or by winds that blow in some cavern with which they communicate. Loch Lomond, in Scotland, and Lake Wetter, in Sweden, are often violently agitated during the calmest weather. The floating islands which exist in several lakes, seem to have been formed by the water first undermining and then detaching from the bank very light earth of the nature of peat; sometimes they are merely reeds and roots of trees woven together. Those of the lake of

---

* By means of observations made with the barometer upon the coasts of the several seas, the surface of the Caspian was ascertained to be 306 feet below that of the Baltic, and nearly 345 below that of the Black Sea.

Gerdau, in Prussia, are said to yield pasturage for one hundred head of cattle; and in the lake of Kolk, in Osnabruck, there is one which is covered with elm trees.

On the Changes which take place in the Earth's Surface.—Action of Running Waters.—Breaking down of Coasts.—Encroachment of Sands.—Formation of New Islands.—Volcanoes.—Earthquakes.

FROM the quiet and regular succession of natural events to which we are accustomed, and the repugnance we feel to the idea that it is possible for the course of nature to suffer interruption, we might, without due investigation, almost persuade ourselves that the physical features and condition of the globe possess an unchangeable character. So far, however, is this from being the case, that there is no country wherein traces are not discoverable of the great changes and violent revolutions of which the earth has formerly been the theatre. The confusion often exhibited in the position of the different strata or layers of which the crust of the earth is composed, the frequent discovery of the remains of animals and vegetables deeply buried in the soil, and many other appearances, testify that the surface of the globe has undergone convulsions, to the production of which none of the natural agents with which we are acquainted can be regarded as adequate; unless they once acted in a method, and with an extent of violence, of which it is impossible for us, by reference to what now exists, to form a conception. "The lowest and most level parts of the earth exhibit nothing, even when penetrated to a very great depth, but horizontal strata, composed of substances more or less varied, and containing almost all of them innumerable *marine productions*. Similar strata, with the same kind of productions, compose the lesser hills to a considerable height. Sometimes the shells are so numerous as to constitute of themselves the entire mass of the rock; they rise to elevations superior to the level of every part of the ocean, and are found in places where no sea could have carried them at the present day, under any circumstances;* they are not only enveloped in loose sand, but are often inclosed in the hardest rocks. Every part of the earth, every continent, every island of any extent, exhibits the same phenomenon." *(Cuvier's Essay on the Theory of the Earth.)* The perfect state in which these shells are generally found, and the regularity, thickness, and extent of the beds that contain them, prove that they could not have been deposited in their places by any temporary invasion of the sea, but that the water must have remained there long enough in a state of tranquillity, to have allowed them gradually to deposit themselves. Some of the strata of marine formation are much more *recent* than others; while in the midst of even the oldest strata of this kind, other strata appear full of animal or vegetable remains of *land* or *freshwater* productions. On these accounts, it would seem as if the land, now inhabited by man, had experienced various successive irruptions and retreats of the sea. There are also appearances which lead to the conclusion that the catastrophes which have occasioned these changes have been sudden and violent. To numberless living beings, they were the messengers of destruction, and of many, the very races have been utterly extinguished. Cuvier, the celebrated French geologist and natural historian, from an observation of the *fossil bones* of more than one hundred and fifty quadrupeds, has determined that upwards of ninety of these animals were of kinds *unknown* to naturalists. There can be no doubt that the revolutions in which these animals were destroyed, occasioned great changes of climate in many parts of the earth, and that in some instances, at any rate, the change took place very rapidly. Fossil plants, and animals of similar kinds to some which still exist in warm regions, have been found in countries where the cold is very much beyond what such kinds are capable of sustaining; and in the arctic zone, the carcasses of large quadrupeds have been discovered enveloped in the ice with their skin, hair, and flesh, still remaining, so that the alteration in the climate must have occurred with such suddenness, as to prevent their bodies from being decomposed by putrefaction.

Such are some of the traces that bear witness to the revolutions which the surface of the globe has undergone. These wonderful and destructive events, of the immediate causes of which nothing can be declared with certainty, must have long ceased; but the earth has since experienced, and is still experiencing, changes of a very perceptible kind, which we shall now proceed to notice.

---

* *Fossil shells* have been found on the summits of the Pyrenees; and among the Andes as much as 13 and 14,000 feet above the level of the sea.

Of the several agents which contribute to these changes, water has the widest sphere of activity. In all abrupt and precipitous mountains, fragments of earth and rock are continually falling down from the higher parts, owing to the slow, but effectual action of rains, storms, &c.; and these become rounded by rolling upon each other. These fragments collect upon the sides and at the foot of the mountains, and, on some occasions, when undermined by rivulets *, have been known to slip down in immense masses, and by stopping up the course of rivers, create great devastation. But, without any such extraordinary occurrences as these, the streams that descend along the flanks of elevated grounds carry along with them some portion of the materials of their respective slopes, especially when swelled into violence by rains or the melting of snows; and such as come from mountains sweep down with them even some of the fragments of rock that have been collected in the high valleys. In proportion, however, as these streams reach the more level country, and their channels become more expanded, they deposit the fragments and stones, till at last their waters convey along only particles of mud of the minutest kind. If, therefore, these waters do not run too rapidly into the sea, or the particles in question do not previously settle in some lake through which the rivers pass, the mud is deposited at the sides of their mouths, forming low grounds, by which the shores are prolonged and encroach upon the sea; and when the waves, by casting up sand upon them, assist in their increase, whole provinces are created, capable, from their rich soil, of yielding, in the highest degree, to the support of man, and of being made the seats of wealth and civilization.

It has been concluded, with reason, that the greater part of Lower Egypt owes its formation to the alluvial matter brought down by the Nile, aided by the sand cast up by the sea. M. Dolomieu has endeavoured to show that the tongue of land on which Alexandria was built, (331 years before Christ,) did not exist in the days of Homer; (about 900 B. C.,) and that the lake Mareotis was, at the latter period, a large gulf of the sea. In the time of Strabo, the geographer, who lived about the commencement of the Christian æra, this gulf had been inclosed by land, and is described as a *lake* of six leagues in length. More certainty exists as to the changes that have occurred since that period. The sand thrown up by the sea and wind has formed, near the site of the ancient town, a narrow tongue, on which the modern Alexandria stands. It has blocked up the nearest mouth of the Nile, and reduced the lake Mareotis almost to nothing; while the rest of the shore has been very much extended by the continual deposition of alluvial matter. In the time of the ancients, the Canopian and Pelusian were the principal mouths of the Nile,† and the coast ran in a straight line from the one to the other. The water now passes out chiefly through the Bolbitian and Phatnitic mouths; and round them the greatest depositions have taken place, to which the coast is indebted for its swelling outline. The cities of Rosetta and Damietta, which were built upon these mouths close to the sea, less than 1000 years back, are now six miles distant from it. At the same time that the sediment of the Nile occasions an extension of the land, both the bed of the river and the country, which is periodically covered by the overflow of the waters, are, from the same cause, gradually being raised to a greater elevation. As a proof of this elevation of the soil, it is stated that at Cairo, before the rise of the river is deemed sufficient for the purpose of irrigation, its height must exceed by 3½ feet that which was requisite ten centuries ago. According to this statement, the ground must have been raised at the rate of nearly 4¼ inches in a century. The ancient monuments of the land all have their bases, more or less, covered by the mud which has been, for ages, accumulating around them.

---

* Large masses of rock have, however, been known to detach themselves, and roll down from mountains without any apparent cause.

In Mr. Bakewell's Travels, vol. I., p. 195—202, there is an interesting description of the fall of a part of Mont Grenier, in Savoy, which took place in 1248. The ruins spread over an extent of nine square miles, and entirely buried five parishes, and the town and church of St. André. Some of the small hills or rocks, of which the ruins consist, are at the distance of three and four miles from the mountains from which they were separated. This catastrophe, Mr. Bakewell remarks, must have been caused by the gradual decay of the soft strata, of which the lower part of the mountain consists; whereby the mass of limestone above was undermined, and becoming detached, fell with destructive violence into the plain. There are appearances about Mont Grenier which threaten a renewal of the catastrophe of 1248.

† The Canopian or westernmost mouth, which used to discharge itself into the sea not far from the site of Aboukir, is now lost in the lake of Etkoo; the Pelusian, the easternmost mouth of the Nile still exists, but in a very insignificant state, flowing through the lake Menzaleh.

The delta of the Rhone undergoes a similar augmentation, and it would appear that the arms of that river have, in the course of 1800 years, become longer by three leagues; and that many places which were once situated on the brink of the sea, or of large pools, are now several miles distant from the water. In Holland and Italy, the Rhine and the Po, since they have been banked up by dikes, raise their beds and push forward their mouths into the sea with great rapidity. Many cities which, at periods within the range of history, were flourishing sea-ports, have, by the encroachments on the water, been deprived of their importance. It is with extreme difficulty that the Venetians are able to preserve the *lagunes* * by which their city is separated from the main land; and in all probability Venice is destined to experience the fate of Ravenna, which, according to Strabo, stood among lagunes in the time of the Roman emperor Augustus, but is now a league from the shore. M. Cuvier records some curious information which he obtained from M. de Prony, inspector-general of bridges and roads, who was appointed to investigate the remedies that might be applied to the devastations committed by the floods of the Po. This clearly displays some of the surprising changes which the coast of the Adriatic has undergone. At the beginning of the twelfth century, the whole waters of the Po flowed to the south of Ferrara, in the two channels called Po di Volano, and Po di Primaro; an irruption of the river to the north of that city happened not long after, and owing to this new direction of the stream, the two old channels in question had, in less than 100 years, been reduced to the comparative insignificance in which they still remain. Since the construction of the grand embankments of the Po, the formation of New Land has proceeded very rapidly, especially within the last two centuries. Such indeed has been the increase, that the city of Adria, which there is no doubt was, at a very remote date, seated on the coast of the *Adriatic*, is now more than fifteen miles distant from the nearest part of it. The distance from the same city to the extreme point of the promontory of the alluvial land, deposited round what is now the principal mouth of the Po, is upwards of twenty miles. At the same time that river has so much raised the level of its bottom, that the surface of its waters is now higher than the roofs of the houses in Ferrara; and the Adige and the Po are higher than the whole tract of country lying between them. The high level above the surrounding plain, attained by the Rhine and the Meuse in Holland, since they have been banked up; the additions of land that have been made along the shores of the North Sea, in Holstein, Friesland, Groningen, &c.; and the diminution of the sea of Azof, by the entrance of alluvial matter from the Don, are further instances of the changes which nature is able to produce by the most simple means. The *Yellow Sea* (so named from its waters being coloured by an intermixture of particles of yellow mud) affords a similar example. This sea, which lies between the peninsula of Corea and the eastern coast of China, is exceedingly shallow, as may be seen from the account of Capt. Hall, who navigated it in the year 1816—(*Voyage to Loo-Choo*, &c.) That officer states, that no land could be perceived from the mast-head at the time when his ship was in less than five fathoms water: and, before a sight of land was obtained, even this depth was considerably reduced. The bottom consisted of mud, formed of an impalpable powder, without the least sand or gravel. The fine particles, from which this mud is deposited, are brought down by innumerable streams from China and Tartary.

The alterations perceived to be taking place in many of those lakes which are traversed by rivers, proceed from the same cause as the extensions of alluvial land into the sea which we have just been considering. The matter brought down by rivers easily settles in the still water of lakes, and the necessary result is, that the basins of the latter are gradually undergoing a diminution. This process, carried on for a sufficient length of time, would end in the filling up of the lake, and in its place there would be a valley intersected, of course, by the same rivers which formerly flowed into the lake. Owing to the very long time required for the purpose, there is no instance known of a lake, of any size, ever having been filled up in this manner; but there are well authenticated cases of their being very sensibly diminished. Lake Erie, one of the vast bodies of water in North America, is rapidly decreasing; in the late survey of the boundaries between the United States and Canada, it was ascertained that Long Point, opposite Big Creek river, on the north side of the lake, had, in the space of three years, increased more than that number of miles in length by the accession of alluvial matter; and this immense basin, the average depth of which is estimated at between thirteen and seventeen fathoms, is every year becoming shallower from the influx of pebbles and earth, and the constant accumulation of reeds and shells. The diminution of the beautiful lake of Geneva is also said to have been considerable within the memory of man.

---

* These are very extensive sheets of water, but so shallow that they, in no part, exceed six or seven feet in depth.

There are several instances in mountainous and marshy countries of small lakes having been dried up from different causes—such as the crystallization, or deposit of substances which the waters had previously held in solution; the gradual union of floating islands, and the collection of matter arising from the lake being the seat of animal and vegetable life; but it is evident, from their very slow progress, that the effects produced in these ways cannot be upon a very large scale.

The changes which we have hitherto traced to the action of waters have been of a beneficial kind; but others of a destructive nature are brought about by the same agency. These are the breaking down of steep coasts by the waves, and the throwing up of sand-hills, which the winds afterwards assist in pushing forward and dispersing over the adjacent land. The first is a very common occurrence; the sea detaches fragments from the foot of the cliffs, or else wastes it away, and then the upper parts, deprived of support, fall down. The broken portions that collect at the base, in consequence of these fallings down, serve, more or less, and for a shorter or longer period, according to their position and hardness of material, to protect the cliff from further ravages. The circumstances also which cause the slipping down or breaking away of masses of rock and earth, among mountains, operate in a similar manner where there are shores of a steep character. Springs filter through and displace the soft strata, and thus the more solid formations are left without support; the consequence is that, at times, large spaces of land slide or fall down from above. It is by such means as these that the 'land-slips,' on the southern shore of the Isle of Wight, have been produced. The same thing happens, but on a far grander scale, upon the coast of the Crimea; whole tracts are there carried down, sometimes bearing upon them the houses of the natives, which have, notwithstanding, been known to escape without injury.

The action of the sea, when the coast is low, and the bottom sandy, leads to very different results. The waves then push the sand forward upon the shore, where, at every ebb of the tide, it becomes partially dried; and the wind, frequently blowing from the sea, drifts it upon the beach. By little and little, hillocks or downs of sand are created, the higher parts of which are continually carried inland; so that unless the inhabitants of the country succeed in fixing them by causing suitable plants to take root in their soil, they move slowly on and overwhelm fields and dwellings with inevitable ruin. It sometimes happens that the sand cast up by the water becomes mixed with marine and other substances, which, being enveloped therein, make what have been denominated *indurated*, that is, *hardened* downs, such as are seen upon the coast of New Holland. Perhaps the most remarkable instance of the mischief occasioned by the moving downs is to be found on the French coast of the Bay of Biscay, south of the river Gironde, where they have already overwhelmed a great number of villages mentioned in the records of the middle age, and not long ago, in the single department of the *Landes*, were threatening ten with unavoidable destruction. One of these villages, named Mimisan, had been struggling against them for twenty years, with the prospect of a sand-hill of more than sixty feet in height visibly approaching it. In 1802, the pools formed by the collection of waters which these downs prevent from flowing into the sea, covered five farming establishments at the village of St. Julien. They have long been over an ancient Roman road leading from Bayonne to Bourdeaux, and which could still be seen forty years back, when the waters were low. The river Adour is now turned to the distance of more than 2000 yards out of its former course. The progress of these downs has been estimated at 60 feet yearly, and in some places, at 72 feet; at this rate, it is calculated that it will require 2000 years to enable them to reach Bourdeaux.

The coast of Elgin or Morayshire, in Scotland, also affords a striking example of the sand-flood; an account of which is given among the notes affixed to Professor Jameson's edition of Cuvier's Theory of the Earth. West of the mouth of the river Findhorn, a district of more than ten square miles in area, (chiefly included in the barony of Coubine,) which, on account of its extreme fertility, was once termed the granary of Moray, has been depopulated and rendered unproductive by the shifting of the sand-hills. It appears that the irruption of the sand commenced about the year 1677; that in 1697, not a vestige was to be seen of the manor-place, orchards, and offices of Coubine, and that two thirds of the barony were already ruined. This irruption came from Mavieston, situated on the shore, about seven miles west from the mouth of the Findhorn, where, from time immemorial, there had been large heaps of sand. These sands, which had formerly been covered with vegetation, were set at liberty by the inhabitants inconsiderately pulling up the bent and juniper for various uses, and they then drifted towards the north-east. When the wind is high, the fine particles are carried even across the bay of Findhorn. In the winter of 1816, a large portion of the only remaining farm, on the west side of the Findhorn, situated in the line of the sand's progress, was overwhelmed. The effects produced by the sand upon the river have been, and still are, of a very obvious kind. Many years ago, its mouth having become blocked up, the water cut out its present more direct channel. By this change, the old town of Findhorn, which originally stood on the east side of the river, was left upon its western bank; and the inhabitants, in consequence, removed the stones of their houses across the new channel, and erected the present village on the eastern side. The site of the old town is now covered by the sea. Even now, when the tide retires, the river almost disappears, being absorbed by the sand; and owing to the bar formed across its entrance, it is unable, at spring tides, to force its way into the sea, so that it is made to flow back and inundate a considerable extent of land at the head of the bay. Of late, however, the great accumulations of sand have disappeared from Coubine, and the ancient rich soil has, in some places, been left bare, from which it is hoped that the barony will again become serviceable land. Such a result would be rendered much more certain, if, by putting in proper kinds of plants, they were to fix the surface of the Mavieston hills, and so prevent fresh inroads of the sand from that quarter; yet, notwithstanding the destruction that has already happened, the inhabitants are still in the habit of gathering what little bent yet remains.

The same drifting of sand occurs upon several parts of the west coast of the Outer Hebrides, and the prevention of it has been attempted in two ways. Mr. A. Macleod, surgeon of North Uist, has invented the most efficacious plan, which is that of cutting thin square turfs from the neighbouring pasture grounds, and laying them down at intervals of some inches. In the course of a few years the turfs grow together, while the ground, from which they are taken, is little injured, for as the roots remain in it, a new vegetation soon rises up. The other method was introduced by Mr. Macleod, of Harris, and tried extensively upon his estate: it is to plant small bundles of *arundo arenaria*, (sand-reed) about a foot and a half apart; these take root and prevent the drifting, in a certain degree.

Another process, similar in its effects to those which have been already described, but much more extensively destructive, and depending solely upon the action of the wind, is the encroachment of the sands of the Libyan desert upon the cultivated lands of Egypt. These sands, driven by the west winds, have left no soil capable of tillage on any parts of the western banks of the Nile, which are destitute of the shelter of mountains. It would appear that, but for the ridge called the Libyan chain, which borders the left bank of that river, forming to the parts along which it runs a barrier against the sands, the western shores of the Nile would, long ago, have been made uninhabitable. Travellers have given a melancholy picture of the traces which bear witness to the ravages committed by the sand—the ruins of numerous cities and villages destroyed, and the summits of the minarets of mosques, being still visible above the surface. It is partly to these resistless invasions of the desert that the decline of Egypt from her ancient splendour is to be attributed.

The formation of new islands (to which allusion has been made in a preceding part of this treatise) constitutes a distinct and interesting class among the changes to which the surface of the globe is subject. Those which have been raised up by volcanic agency are, comparatively, few; but those of coral, which owe their origin to marine insects, (of the class of zoöphytes or *plant-animals*) are innumerable. Of the different coral tribes, the most abundant is that named the madrèpore. It is most common in the tropical seas, and decreases in number and variety towards the poles; it surrounds, in vast rocks and reefs, many of the rocky islands of the South Sea and Indian Ocean, and increases their size by its daily growth. The coasts of the islands in the West Indies, of those to the east of Africa, and the shores and shoals of the Red Sea, are encircled with rocks of coral. Several navigators have furnished us with accounts of the curious manner in which these formations take place: the following is extracted from Captain Basil Hall's narrative of his voyage to the Loo Choo islands:—

"The examination of a coral reef, during the different stages of one tide, is particularly interesting. When the tide has left it for some time, it becomes dry, and appears to be a compact rock exceedingly hard and rugged; but as the tide rises, and the waves begin to wash over it, the coral worms protrude themselves from holes which were before invisible. These animals are of a great variety of shapes and sizes, and in such prodigious numbers, that, in a short time, the whole surface of the rock appears to be alive and in motion. The most common of the worms at Loo-Choo is in the form of a star, with arms from four to six inches long, which are moved about with a rapid motion, in all directions, probably to catch food. Others are so sluggish, that they may be mistaken for pieces of the rock, and are generally of a dark colour, and from four to five inches long, and two to three round. When the coral is broken, about high water mark, it is a solid hard stone; but if any part of it be detached at a spot which the tide reaches every day, it is found to be full of worms of different lengths and colours: some being as fine as a thread, and several feet long, of a bright yellow, and sometimes of a blue colour; others resemble snails, and some are not unlike lobsters in shape, but soft, and not above two inches long.

"The growth of coral appears to cease when the worm is no longer exposed to the washing of the sea. Thus, a reef rises in the form of a cauliflower, till its top has gained the level of the highest tides, above which the worm has no power to advance, and the reef, of course, no longer extends itself upwards. The other parts, in succession, reach the surface, and there stop, forming, in time, a level field with steep sides all round. The reef, however, continually increases, and being prevented from going higher, extends itself laterally in all directions. But this growth being as rapid at the upper edge as it is lower down, the steepness of the face of the reef is still preserved. These are the circumstances which render coral reefs so dangerous in navigation; for, in the first place, they are seldom seen above the water; and in the next, their sides are so steep, that a ship's bows may strike against the rock, before any change of soundings has given warning of the danger."

Captain Flinders, who, in 1801, made a survey of the coasts of New Holland, has some observations upon the formation of coral islands, particularly of Half-Way island, on the north coast of that region, which show how, after being raised up, they gradually acquire a soil and vegetation:—

"This little island, or rather the surrounding reef, which is three or four miles long, affords shelter from the south-east winds; and being at a moderate day's run from Murray's Isles, it forms a convenient anchorage for the night to a ship passing through Torres' Strait—I named it *Half-way Island.* It is scarcely more than a mile in circumference, but appears to be increasing both in elevation and extent. At no very distant period of time, it was one of those banks produced by the washing up of sand and broken coral, of which most reefs afford instances, and those of Torres' Strait a great many. These banks are in different stages of progress; some, like this, are become islands, but not yet habitable; some are above high-water mark, but destitute of vegetation; whilst others are overflowed with every returning tide.

"It seems to me, that when the animalcules which form the corals at the bottom of the ocean cease to live, their structures adhere to each other, by virtue either of the glutinous remains within, or of some property in salt water; and the interstices being gradually filled up with sand and broken pieces of coral washed by the sea, which also adhere, a mass of rock is at length formed. Future races of these animalcules erect their habitations upon the rising bank, and die in their turn, to increase, but principally to elevate this monument of their wonderful labours. The care taken to work perpendicularly in the early stages would mark a surprising instinct in these diminutive creatures. Their wall of coral, for the most part in situations where the winds are constant, being arrived at the surface, affords a shelter, to leeward of which their infant colonies may be safely sent forth; and to this, their instinctive foresight, it seems to be owing, that the windward side of a reef exposed to the open sea is generally, if not always, the highest part, and rises almost perpendicular from the depth of many fathoms. To be constantly covered with water seems necessary to the existence of the animalcules, for they do not work, except in holes upon the reef, beyond low-water mark; but the coral, sand, and other broken remnants thrown up by the sea, adhere to the rock, and form a solid mass with it, as high as the common tides reach. That elevation surpassed, the future remnants, being rarely covered, lose their adhesive property; and remaining in a loose state, form what is usually called a *Key*, upon the top of the reef. The new bank is not long in being visited by sea-birds: salt plants take root upon it, and a soil begins to be formed; a cocoa-nut, or the drupe of a pandanus, is thrown on shore; land birds visit it, and deposit the seeds of shrubs and trees; every high tide, and still more every gale, adds something to the bank; the form of an island is gradually assumed; and last of all, comes man to take possession.

"Half-way Island is well advanced in the above progressive state; having been many years, probably some ages, above the reach of the highest spring tides, or the wash of the surf in the heaviest gales. I distinguished, however, in the rock which forms its basis, the sand, coral, and shells, formerly thrown up, in a more or less perfect state of cohesion. Small pieces of wood, pumice stone, and other extraneous bodies which chance had mixed with the calcareous substances when the cohesion began, were inclosed in the rock, and, in some cases, were still separable from it without much force. The upper part of the island is a mixture of the same substances in a loose state, with a little vegetable soil; and is covered with the *casuarina* and a variety of other trees and shrubs, which give food to parroquets, pigeons, and some other birds; to whose ancestors, it is probable, the island was originally indebted for this vegetation."

It has been generally believed that the deep perpendicular reefs, very near to which the sounding line finds no bottom, consist wholly of coral; but MM. Quoy and Gaimard have adduced very satisfactory reasons, to prove that the zoöphytes, far from raising from the depths of the ocean perpendicular walls, form only layers or crusts of a few fathoms thickness. They remark that the species which always construct the most considerable banks require the influence of light to perfect them; and it is well known, that all those steep walls common in the equatorial seas, are intersected with narrow and deep openings, through which the sea enters and retires with violence; whereas, if they were entirely composed of madrepores, they would have no such openings between them, since it is the property of zoöphytes to build in masses that have no interruption. It is besides, difficult to suppose that these animals can support such different degrees of pressure and temperature as they necessarily must, if they exist at such different depths in the ocean. It is, therefore, most reasonable to conclude that the summits of submarine hills and mountains are the bases upon which the zoöphytes form layers and raise up their fabrics; a supposition which perfectly accounts for the great depth of the sea close to the reefs and islands which they have elevated to the surface of the water.

The changes occasioned by the eruptions of volcanoes are very considerable near the seat of action, but they operate over a less extensive field than any of those which have yet been mentioned.

The principal effect of the issue of subterranean fires is the elevation of the surface of the surrounding country; and the size of the mountains themselves must have been prodigiously increased by the matter thrown up during successive eruptions. Some, indeed, have gone so far as to assert that volcanoes are *entirely formed* of this matter; but even if we could admit such a theory, with respect to the isolated volcanoes of Europe, Asia, and the African islands, it would be impossible to extend it to those immense masses in America (Cotopaxi, Pichincha, &c.) which are parts of the great western chain of that continent. There are, nevertheless, very good grounds for concluding that many volcanoes owe their formation to the effects of the fires to which they give vent, and that, previous to the first appearance of those fires, there were no mountains in the places which the volcanoes in question now occupy. It would seem that the breaking out of a volcano, where none before existed, is preceded by a swelling or heaving up of the crust of the earth, owing to the expansive force of the heat, and this explains the cause of new volcanic islands sometimes emerging suddenly from the sea. The phenomenon of the swelling up of the ground was strikingly exemplified when the volcano of Jorullo, in Mexico, arose out of the plain des Playas, in the month of September, 1759. According to the representation of this mountain, annexed to the third volume of M. Humboldt's Personal Narrative, the raised up portion of the plain is about two miles in length, and in one part as much as 850 feet above its ancient level; from this part. the cone of the volcano shoots up covered with ashes to a further elevation of 830 feet. The raised up ground is covered with thousands of small volcanic cones, from 6 to 10 feet high. We have thus an instance of a mountain 1680 feet in elevation above the plain upon which it stands, having been entirely formed by the heaving up of the earth when the fire originally broke out, and by the accumulation of matter which has since gathered round the principal vent of the eruptions. But the knowledge of such an instance as this does not of necessity lead to the conclusion that mountains so large as Etna, and many other volcanoes, have been entirely created by the process which gave birth to Jorullo: yet, though it might be rather hazardous to adopt such a conclusion, it is certain that those mountains must have received a vast increase, both in size and elevation, at and since the period, whenever that may have been, at which the subterranean fire first opened a passage through them.

Owing to the repeated discharges of matter upon their surface, and the violent concussions to which they are subject, the external appearance of volcanic mountains is continually varying. This is particularly the case with Etna. Among the accounts of those who have visited it, it would be difficult to find two that at all agree as to the aspect of the great crater and the different eminences about the summit of the mountain. New chasms on the sides also have, at various periods, been opened, and new cones raised up: Monte Russo, thrown up from a plain during the famous eruption of 1669, was estimated by Spallanzani, in 1788, at two miles in circumference, and (somewhat vaguely) at 150 paces in height.

The lava, stones, and ashes spread over the neighbouring country by volcanoes materially elevate its surface. The complete burial of the ancient cities of Herculaneum and Pompeii by the matter ejected from Vesuvius, in the eruption of the year 79, is a circumstance familiar to almost every one. The excavation of these cities in modern days has brought some interesting facts to light; the ruins of Herculaneum were found at a depth of 70 feet below the surface of the ground; and from the number of distinct strata of lava, one above the other, each covered with a layer of rich mould, it appeared that streams of that substance from, at least, six different eruptions had passed over it since the one which occasioned its destruction.

Vast masses of earth sometimes sink down during volcanic eruptions. In the island of Timor, a volcano of considerable elevation is said to have sunk into the ground, leaving a muddy marsh in its place. The *Papandáyang*, situated towards the western extremity of Java, was formerly one of the largest volcanic mountains of the island, but the greatest part of it was swallowed up in the earth in the year 1772. It is asserted, that, on the night of this event, an uncommonly luminous cloud was seen to envelop the mountain. Alarmed by this appearance, the inhabitants on the declivities and about the foot of the mountain took to flight, but before they could all save themselves, it began to give way, and the greatest part of it actually *fell in* and disappeared in the earth. A tremendous noise, and the discharge of showers of volcanic substances, accompanied this commotion. It is estimated, that an extent of ground, of the mountain itself and its immediate environs, 15 miles long and 6 broad, was swallowed up in the bowels of the earth.

Of the origin of the volcanic fire, nothing, of course, can be affirmed with certainty; but several explanations have been offered, more or less satisfactory. An attentive observance of the phenomena connected with eruptions, and a close examination of the substances ejected, are necessary to the attainment of any correct views upon the subject. It has been a very generally received opinion that volcanic eruptions are caused by the spontaneous combustion of pyrites; and in support of this solution are cited the experiments which have been made with sulphur and iron filings. A mixture of these substances, after being moistened, has been buried in the ground, where it became gradually heated, and at length took fire, with a loud explosion. The theory, however, which ascribes volcanic action to the inflammation of beds of coal, sulphur, or other matters, near the surface of the earth, has latterly met with less support, and powerful arguments may be urged against it. The great masses of inflammable materials are confined to the secondary and superficial strata; while, on the contrary, there can be no doubt, that the seat of volcanic fire lies far below the surface of the earth, both from the nature of the substances cast out by volcanoes, and the circumstance of the immense quantity of matter that has proceeded from many of them; such a quantity as, had it been withdrawn from the parts near the surface, would, long since, have occasioned those mountains to sink down and disappear. A different theory has been lately brought forward to account for the volcanic fire, and is well set forth and supported in a recent treatise by Dr. Daubeny, Professor of Chemistry in the University of Oxford. It is founded upon the metallic nature of the bases of the earths and alkalies, and the avidity with which these combine with oxygen, producing in that combination a high temperature and strong inflammation. It is supposed, that if these materials exist in sufficient quantity in the interior of the earth, and a sufficient body of water be admitted to them, judging from the violent effects on a small scale which we are able to produce by experiments, a heat would be engendered quite adequate to occasion all that takes place in volcanic eruptions. Now, under this hypothesis, it is requisite that water should have access to the metallic bases, and it is a curious fact that nearly all active volcanic groups are within a short distance of the sea; while even those in South America, which must be excepted from this remark, are in a range of mountains approaching in parts close to the sea. *Extinct* volcanoes, it is true, are found in situations quite beyond the access of the present ocean; but in the remote and unknown periods of their activity, it may reasonably be inferred that they were near the ocean, if not altogether beneath its surface. A further argument in favour of the present view is, that all the products which chemists know to be the result of the admission of sea-water to the metallic bases, appear under some form or other in every volcanic eruption.

Earthquakes appear to be brought about by the same causes as volcanic eruptions, but their action is much more tremendous than that of the latter. They are frequently accompanied by loud subterraneous noises, and are sometimes so violent that the ground heaves up, and undulates like an agitated sea. They are felt almost at the same instant over a most astonishing extent; though happily, compared with this extent, their destructive ravages are confined within a small range. In those parts which appear to be near the centre of their action, the most calamitous effects sometimes occur; whole cities are destroyed, and their inhabitants buried beneath the ruins; the surface of the ground undergoes violent changes; springs are stopped, and others gush out in new places; fissures are made in the earth; and enormous masses of rock and other materials sink down, or are detached from the mountains. By the earthquake experienced in Chili in 1822, a great line of coast is stated to have been lifted permanently up, to the height of several feet above its former level; while, in the interior of the country, fissures were made in the granite transversely to the direction of the earthquake.

It is generally supposed that earthquakes are produced by the disengagement of elastic vapours, which, endeavouring to escape from their confinement, heave up and agitate the crust of the earth. No doubt can exist of their connexion with volcanic eruptions; their frequency in countries where the latter take place, and the fact of the one often occurring at the same period as the other, sometimes at great distances apart, tend to establish such a connection. This is further shown by the circumstance of the shocks of earthquakes being most severe in places distant from volcanoes; as if the latter were the means of giving vent to that elastic force, which, when pent up, causes such dreadful ravages. It is also worthy of notice, that though earthquakes are sometimes felt towards the interior of continents, their terrible effects occur chiefly along the coasts, as exemplified in the earthquakes of Lima, of Lisbon, of Caraccas, and many others.

Such are the principal changes which the surface of the globe is now undergoing. It is evident, notwithstanding what some have been inclined to assert, that they could not have brought about those grand revolutions which formerly visited the earth, and in which such multitudes of the animal race were consigned to destruction. The whole of them are insufficient to alter, in any perceptible degree, the level of the sea, still less to have occasioned an overwhelming of the land by that element. Some philosophers have endeavoured to prove that a gradual and general lowering of the level of the sea takes place, and have appealed to certain observations which, if correct, tend to establish the fact of a diminution of the waters along the northern shores of the Baltic. But it must not be forgotten, that though in some places the ocean has retired, or sunk in level, in others it has encroached upon the land; while it is known that many harbours of the Mediterranean have preserved exactly the same level since the time of the ancients. It is plain, therefore, that all variations upon the coasts of the ocean are merely of a local kind, and that if the different accounts are balanced, we must arrive at the conclusion, that the general volume of the ocean, and perhaps even its superficial extent, suffer neither increase nor diminution.

On the Ocean—its Saltness, and Temperature, Tides, and Currents.

That vast body of water which surrounds the continents, and is the common receptacle of their running waters, is indispensably necessary to the support of animal and vegetable existence upon the earth. Its perpetual agitations purify the air, and the vapours which the atmosphere draws up from its surface, being condensed and dispersed through the upper regions, form clouds, which are the source of a constant supply of rain and moisture to the land. The ocean also, by the facilities for communication which it offers, is the means of uniting the most distant nations, while it enables them to interchange with mutual advantage the productions of their several climates.

The bottom of the sea appears to have similar inequalities to the surface of the continents; the depth of the water is, therefore, extremely various. There are vast spaces where no bottom has been found, but this, of course, does not prove that the sea is bottomless, because the line is able to reach but a comparatively small depth. Lord Mulgrave, in the Northern Ocean, let down a very heavy sounding lead, and gave out with it nearly 4700 feet of rope without finding the bottom; and Mr. Scoresby mentions having sounded in the Greenland sea as much as 7200 feet. Such experiments, however, must be of very doubtful character; it is well known how much more easily bodies may be moved along in the water than in the atmosphere, and, consequently, any current would be sufficient to carry the lead with it, and so draw the rope out of a perpendicular direction. If we were to found our opinion upon analogy, we might conclude that the greatest depth of the ocean is, at least, equal to the height of the loftiest mountains, that is, between 20,000 and 30,000 feet.

The level of the sea, if it were not for the action of external disturbing causes, would be the same every where at the same instant, owing to the equal pressure exerted by the particles of a fluid upon each other in every direction. The figure assumed by the ocean would, therefore, exhibit the true surface of our planet, that of an oblate spheroid. But it is evident that no general level of this kind can ever exist, because the tide at any given moment is at very different heights in different parts of the ocean. The level is also continually being disturbed by the operation of the wind in particular regions. Independent, however, of these circumstances, it would appear that in gulfs and inland seas which have only a slight communication with the ocean, the level of the water is usually more elevated than in the latter. This seems to be more especially the case if the only openings of these gulfs are towards the east; and it is attributed with reason to the accumulation which arises from the water being driven into these confined inlets by the general movement of the sea from east to west, a movement to which allusion will be made presently. When the French engineers were in Egypt, they made observations, according to which the waters of the Red Sea, on the east side of the isthmus of Suez, were 32½ feet higher than those of the Mediterranean on the opposite shore of the same isthmus. M. Humboldt made observations of a similar kind upon the isthmus of Panama, and his conclusion is that the waters of the Gulf of Mexico are from 20 to 23 feet higher than those of the Pacific on the other side. Of certain inland seas the level varies with the seasons; the Baltic and the Black Sea, which are in fact almost lakes, swell in the spring, from the abundance of water brought down to them at that period by the rivers.

The general colour of the sea is a deep bluish green, which becomes clearer towards the coasts. This colour is thought to arise entirely from the same cause as the azure tint of the sky; the rays of blue light, being the most refrangible, pass in the greatest quantity through the water, which, on account of its density and depth, makes them undergo a strong refraction. The other colours exhibited in parts of the sea depend on causes which are local, and sometimes deceptive. The Mediterranean in its upper part is said to have at times a purple tint. In the Gulf of Guinea the sea is white; around the Maldive Islands it is black; and in some places it has been observed to be red. These appearances are probably occasioned by vast numbers of minute marine insects, by the nature of the soil, or by the infusion of certain earthy substances in the water. The green and yellow shades of the sea proceed frequently from the existence of marine vegetables at or near the surface.

The water of the sea contains several extraneous substances, in proportions varying in different places. The component parts, in addition to pure water, are commonly muriatic or marine acid, sulphuric acid (vitriol), fixed mineral alkali, magnesia, and sulphated lime. By boiling or evaporation in the air, common salt (muriate of soda) is obtained, which for salting meat is preferred to the salt of springs. The saltness of the sea appears, with some local exceptions, to be less towards the poles than near the tropics; but the difference is very slight, and perhaps the observations made are not sufficiently numerous to justify any positive general conclusions. It is probably occasioned by the melting of the ice in the polar seas. Dr. Thomson (*Work on Chemistry*) states the proportion of salt in water taken up by Lord Mulgrave at the back of Yarmouth sands, at 3.125 per cent. of the weight of the water. He also gives, from the accounts of different observers, the following proportions:—

				Quantity of saline matter.						
N. Lat.	80°	(60 fathoms	under ice)	3.54	per cent.	S. Lat.	49°	50′	4·16	per cent.
"	74	"	"	3·60	"	"	46		4·50	"
"	60	"	"	3·40	"	"	40	30	4·00	"
"	45	"	"	4·00	"	"	25	54	do.	"
"	39	"	"	do.	"	"	20		3·90	"
"	34	"	"	do.	"	"	1	16	3·50	"
"	14	"	"	do.	"					

Mr. Scoresby, in north latitude 77° 40′, and east longitude 2° 30′, found, in a quantity of water taken from the surface, the proportion of saline matter 3·56 per cent. A statement in the Edinburgh Philosophical Journal gives the proportion in north lat. 64° 26′, east long. 0° 38′, 3·54 per cent.; in north lat. 78½°, east long. 6½°, 3·88; and in north lat. 78° 35′, east long. 6°, 3·27. Some observations which have been made tend to prove that the sea is less salt at the surface than towards the bottom.

The following table of the proportional specific gravities of different kinds of water, explains the reason of bodies being so much more buoyant in the sea than in other water: —

Distilled water . .	1·000
Purest spring water .	1·001 to 1·005
River water	1·010
Sea water	1·028

The degree of saltness in particular parts of the sea frequently varies from temporary causes. The violent tropical rains have an effect in diminishing it, especially near coasts, where an increased volume of fresh water is brought down by the rivers. The Baltic is at all times less salt than the ocean, and when a strong east wind keeps out the North sea, its waters are said tobecome almost fit for domestic uses. The most curious phenomenon of all is that of springs of fresh water rising up in the midst of the sea; Humboldt mentions that in the Bay of Xagua, on the southern coast of Cuba, springs of this kind gush up with great force at the distance of two or three miles from the land.

The bitterness which exists in sea-water, but apparently not beyond a certain depth, is with much probability considered to be owing to the vegetable and animal matter held there in a state of decomposition.

Water being a bad conductor of heat, the temperature of the sea changes much less suddenly than that of the atmosphere, and is by no means subject to such extremes as the latter. It may safely be affirmed that the temperature never in any season, or under any latitude, exceeds eighty-five or eighty-six degrees of Fahrenheit's thermometer. The existence of banks or shallows has a local effect in diminishing the temperature of the ocean, but the great agents in modifying it are currents, which mingle together the waters of different depths and regions. Thus the Gulf stream, as it is termed, which sets into the Gulf of Mexico, is much warmer than the neighbouring parts of the sea; the current of Chili is just the reverse

The following tables are extracted from M. Humboldt's Personal Narrative, (Vol. II.;) the experiments from which No. I. was drawn up, were made during the passage from Spain to the New Continent, between the 9th of June and 15th of July 1799:—

(No. I.)

North lat.	West long.	Temp. of the Atl. ocean at its surface.
39° 10′	16° 18′	59° 00′ Fahr.
34 30	16 55	61 34
32 16	17 4	63 86
30 36	16 54	65 48
29 18	16 40	66 74
26 51	19 13	68 00
20 8	28 51	70 16
17 57	33 14	72 32
14 57	44 40	74 66
13 51	49 43	76 46
10 46	60 54	78 44

(No. II.)

Table of the Temperature of the Atlantic Ocean in different degrees of Longitude.

Latitude.	Longitude.	Temp. of the Ocean.	Period of the Observation.	Observers.	Mean Temperature of the Air in the Basin of the Sea
0° 58′ S.	27° 34′ W.	80.96 Fh.	Nov. 1788	Churruca	80°·6 (Cook.)
0 57	30 11	81.86	April 1803	Quevedo	
0 33	21 20	81.86	March 1800	Perrins	
0 11 N.	84 15	82.40	Feb. 1803	Humboldt	
0 13	51 42 E.	80.78	May 1800	Perrins	
25 15 N.	20 36 W.	68.00	June 1799	Humboldt	69·8 (La Pérouse and Dalrymple.)
25 29	39 54	70.88	April 1803	Quevedo	
25 49	26 20	69.26	March 1800	Perrins	
27 40	17 4	70.88	Jan. 1768	Chappe	
28 47	18 17	74.30	Oct. 1788	Churruca	
42 34 N.	15 45 W.	51.98	Feb. 1800	Perrins	54·86 (Cook and d'Entrecasteaux.)
43 17	31 27	59.90	May 1803	Quevedo	
43 58	13 7	60.62	June 1799	Humboldt	
44 58	34 47	54.86	Dec. 1789	Williams	
45 13	4 40	59.90	Nov. 1776	Franklin	
48 11	14 18	57.74	June 1790	Williams	

These tables refer only to the Atlantic ocean; but the experiments which have been made in the South sea, and in the Indian ocean, show that within a certain distance of the equator, the general temperature of the sea follows nearly the same rule in corresponding latitudes. Within the tropics there is no sensible difference in north and in south latitudes; there is very little even as far as the thirty-fifth and fortieth degrees; but, when we advance into high latitudes, there can be no doubt that the sea is colder in the southern than in the northern hemisphere. Ice extends from five to eight degrees of latitude farther from the south than from the north pole, owing, it is probable, to the almost entire absence of land near the Antarctic circle; while the north pole is so nearly surrounded by land, that the ice of the Arctic ocean is shut up, and cannot be carried forward to such a distance by the current which sets towards the equator.

Bays, inland seas, and the spaces among clusters of islands, where the action of the waves is more confined, and the water usually of less depth, are the most favourable places for the production and accumulation of the marine ice. It is on this account that the navigation of the Baltic is annually stopped by the ice in a latitude not more northerly than that of tracts which in the main ocean are always open to the passage of ships. In severe winters, people may travel in sledges across the entrance of the Gulf of Bothnia (lat. 60°) which, including the numerous small intervening islands, is a distance of a hundred and fifteen miles. The body of ice accumulated in Sir James Lancaster's sound has defied all the attempts that have been made to accomplish the north-west passage from the Atlantic to the Pacific.

The ice of the polar seas assumes a great variety of shapes and appearances. The vast and thick sheets which are met with in high latitudes are called *fields* by navigators; they are so extensive, that their boundaries cannot be seen from a ship's mast-head; and Captain Cook found a chain of them joining Eastern Asia to North America. Sheets of less extent than fields are called *floes*. *Bergs* are islands of ice, considerably elevated above the water; and though of the most various forms, commonly perpendicular on one side, and sloping gradually down on the other, in height they are sometimes as much as two hundred feet*. There are two ways of explaining the formation of these bodies. The large masses of ice in the Polar seas, when crowded together by winds and currents, exert such an enormous pressure upon each other, that they are frequently broken, and the fragments are piled up so as to form mounds and ridges of considerable elevation; it is thus that many of the small ice-bergs originate. There is no doubt, however, that the most bulky of these bodies are detached portions of vast glaciers, such as abound on the precipitous coasts of Greenland and Spitzbergen, broken off in consequence either of their own weight, or the undermining action of the waves, and then carried by winds and currents to other parts of the ocean.

When the summer has well advanced, the masses of ice which have been frozen together during the winter gradually separate, and clear spaces of water are left. As soon as the end of September, these open spaces again begin to freeze over; but before this effect commences, the temperature of the air must be very much lowered, owing partly to the freezing point of sea being three and a half degrees (Fahrenheit) below that of common water, but more especially to the surface which the water presents to the atmosphere being repeatedly changed before its temperature is sufficiently reduced for it to freeze. This change in the surface, which is greatly assisted by the agitation of the sea, takes place in consequence of the particles of a liquid body becoming specifically heavier as they get cooled, so that they descend and are succeeded by warmer particles.

There are three kinds of movements constantly going on in the waters of the sea:—1. The agitations which its surface undergoes by the action of winds—2. Tides, which are the result of the attraction exercised on the water by the sun and moon—3. Currents, which arise from different causes, some of them existing within the element itself.

1. As the particles of a fluid press equally in every direction, it follows that when a portion of the surface of the water is displaced by a wind, the adjoining water instantly rushes in to restore the equilibrium or balance which has been destroyed. This accounts for the formation of *waves*. When a violent impulse has thus been communicated, the waves continue in motion for some hours after the gale has entirely subsided, on the same principle as a pendulum continues to swing for some time after it has been set in action. Yet the agitation occasioned by winds extends to comparatively but a little way below

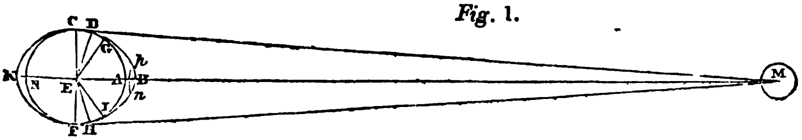
---

* Experiments made in the Arctic Seas show that of a piece of floating ice, the proportion above water is generally about one-seventh of the thickness of the whole mass. It must not, however, be supposed from this, that an iceberg two hundred feet out of the water exhibits only one-seventh of its height, because these bodies are frequently aground.

the surface of the water: divers say that, in the roughest weather, it is calm at the depth of ninety feet.

2. The ***tides*** **proceed from the attractive forces of the sun and moon, which diminish the gravity of the waters of the** ocean, or, which is the same thing, draw or lift up the waters toward themselves. Let E (fig. 1.) represent the earth and M the moon; since the power of gravity increases as the square of the distance diminishes, it is evident that the waters at A, the part of the earth nearest the moon, will most feel the effect of her attraction, and will be raised up to B; while those on each side of A, being farther off, will be less raised. But besides the difference occasioned by a greater or less distance, the more oblique or slanting the line of attraction, the less will be the elevation of the water acted upon, till at last the water towards and under the circle CEF will not only not be elevated but will be lowered. The reason of this is, that the force of attraction acts in straight lines; and, therefore, if we draw two straight lines from the moon's centre, MC, MF, to represent this force acting on the parts C and F, it is obvious that the water at C and at F will not be raised, but depressed by being drawn away from C to D and from F to H; and so of every part of the circle CEF. In the same manner, the water at D and H will pass to G and I, and thus the ocean will be disposed in a spheroidal form CDGBIHF. But the water will, at the same time, rise on the side of the earth away from the moon, because the earth's centre being more strongly drawn towards the moon than the point N, recedes from N, which is the same in effect as if the water at N receded or rose up from the earth's centre. The ocean, therefore, will assume a spheroidal form, CKF, on the side away from the moon, as well as on the one facing her. Thus, if we draw a line MAK from the moon's centre through the centre of the earth, the two points B, K, where it touches the earth's surface, will be those of *high water;* and if we take two more points C, F, equally distant from each of the first two, they will be points of *low water.* By the earth's rotation on its axis the part F will be carried to A and the part C to N; matters will then be just reversed, and it will be high water at F and C, and low water at A and N. According to this it should be high water at any place *in the open sea,* when the moon is upon the meridian of that place, and low water when the moon is upon a circle cutting the meridian in question at right angles; but, in fact, the greatest and least heights of the water at such a place do not occur till about three hours *after* the periods fixed in this supposition. The delay is thus explained: the elevated parts of the sea have received such an impulse towards ascent, that they continue to rise after the earth's rotation has carried them from under the line of the direct attraction of the moon; this impulse being also aided for a time by the moon continuing to attract the water upwards, though in a less degree.

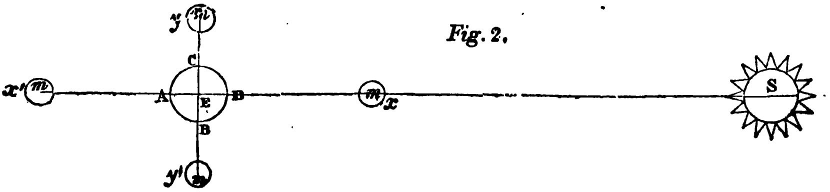
Fig. 1.



As the moon crosses the meridian of a place about every twenty-four hours fifty minutes and a half, the sea in that space of time ebbs twice and flows twice all over the world, although much less towards the poles than within the tropics, where the waters are under the direct line of the lunar attraction.

In the above remarks we have spoken only of the moon, because, though the sun is so very much larger than the moon, yet the latter, on account of her nearness to our planet, has the most powerful effect upon the tides; it is calculated that her influence is nearly triple that of the sun. The sun, however, acts upon the ocean in the same manner, though in a less degree. When these two bodies unite their influence, which they do at the seasons of new and full moon, the tides naturally rise the highest, and are then called *spring tides;* but when the moon is in her quadratures, or quarters, the action of each of the two luminaries is directly opposed to that of the other; the tides are then of course the lowest, and are called *neap*

Fig. 2.

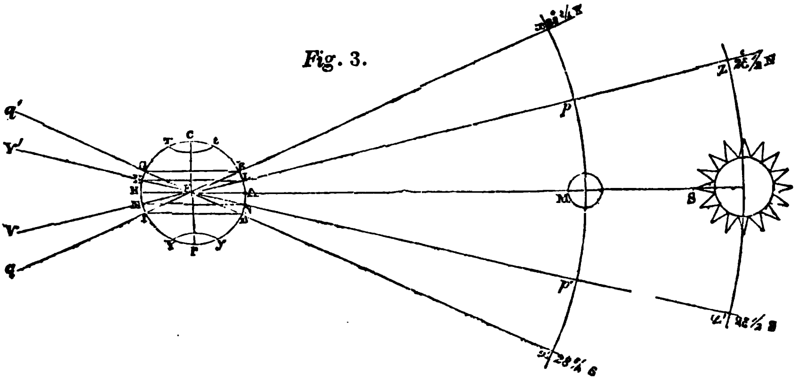


tides. To explain this more clearly, let E (fig. 2) be the earth, S the sun, and *m* the moon; when new, the moon is situated at *x*, when full at *x'*, and when in her quadratures at *y* and *y'*. It results, from what has been already said, that, both at new and full moon, the sun and moon will each assist the other in raising the ocean round A and D, and depressing it at C and B; but when the moon is in her quadratures, her tendency is to raise the waters at C and B and depress them at A and D; while that of the sun is exactly the reverse. During the moon's circuit round the earth, the spring and the neap tides each occur twice, and one after the other.

If the earth were entirely covered by a sea of uniform depth, and the sun and moon moved always in the plane of the equator, the region of the highest tides would always be directly under the equator, while at the poles there would never be any tide whatever. But the changes that occur in the positions of the sun and moon, and several other circumstances, prevent the tides from taking place in so uniform a manner.

In figure 3, let us suppose A E H to be the equator, and C and F the poles of the earth, and let M, the moon, and S, the sun, both be in the plane of the equator; in this case the water will be higher at H and A, than in any other places, and most depressed under the circle C E F. By the earth's rotation, E will come to A, and it will be high water at E, but C and F, the poles, suffer no change of position from the earth's rotation, and the waters there will, consequently, remain just as before. If the sun and moon, therefore, were to remain constantly in the plane of the equator, the highest tideswould always be at A, E, H, &c., that is, under the equator; while, as Cand F would always be situated the same with respect to the sun and moon, it would always be low water at the poles, that is, they would never have any tides at all. The sun and moon, however, are continually changing their positions, with respect both to the equator and to each other, and corresponding variations are produced in the tides. The moon, for instance, is sometimes as much as 28¾ degrees on each side of it. Suppose her to be situated at *x*, 28¾ degrees north of the equator, draw a line from *x* through the centre of the earth, and let it come out at the opposite side of the earth, the points B and I will have the highest tides, and as the earth turns round, all the parts of the circles G B and I D will successively come to B and I. The waters, under those two circles, will,

Fig. 3.



therefore, have the highest lunar tides, (when the moon is at x or x') and the waters, under the circles $T\,t$ and $Y y$, will, in turn, be the most depressed. Results of a similar kind are obtained if we notice the changes of the sun's position. In the course of a year, that luminary ranges nearly 23½ degrees on each side of the equator. Suppose him to be situated at z, 23½ degrees north of it: a line drawn from him, through the earth's centre to the other side, will pass through L and M, and the parts under the circles L K and M N will, while the sun is at z or z', experience the highest solar tides. If, therefore, at the time when the sun is situated at z, or z', the moon happens to be at x, x', q, or q', the sea, under the four circles G B, I D, L K, and M N, will, as the earth moves round, have the highest tides on the globe; the tides of G B and I D being, however, higher than those of L K and M N; since the moon's attraction is more powerful than that of the sun. If again, while the sun is at z, or z', the moon happens to be at p, p', v, or v', the forces of both will combine to raise the tides highest under the two circles L K, M N; and when both luminaries are on the equator together, the circle A E H (that is, the equator) will, alone, be that of the highest tides. It must at the same time be kept in view, that whenever the sun and moon are not situated at the same distances from the equator, so that the circles of their highest tides do not coincide or fall together, allowance must be made for their attractive forces *counteracting*, in some degree, each other's effects upon the ocean; and as the moon completes her range on each side of the equator in about 29½ days, while the sun, to complete his, takes nearly 365¼ days, their combined motions must produce continual irregularities in the tides. Taking one year with another, the mean monthly range of the moon on each side of the equator is the same as the annual range of the sun (23° 28′); the *highest* tides are, consequently, within the tropics, and the *least* within the arctic and antarctic circles.* Within the tropics, the flood tide passes from east to west, (following the apparent course of the sun and moon,) but as the torrid zone is the seat of the highest tides, the flood in the northern temperate zone comes from the south, and in the southern temperate zone from the north. To this rule there are, nevertheless, local exceptions, caused by those derangements of the tide which we are now going to mention.

Of all irregularities in the tides, those are the greatest which are occasioned by the obstacles offered by the land to the ebb and flow of the waters. The impediments created by shallows in the ocean, and by the shores, bays, gulfs, and promontories of islands and continents are such, that the tides are greatly delayed, altered both in degree and in direction, and in many places so accumulated, that they rise to heights far exceeding what is witnessed in the open ocean. On the coasts of the islands of the South Sea, there are regular tides of only one or two feet in elevation; but on the western shores of Europe, and on the eastern shores of Asia, the tides are very strong, and have many variations. On the northern coasts of France, the flow being confined in a channel, and repelled also by the opposite coasts of England, rises to a surprising height; at St. Maloes, in Bretagne, it is said, even to 50 feet. The tide of the German Ocean is twelve hours in travelling from the mouth of the Thames to London Bridge, where it arrives about the time that there is a new tide in the German ocean. This is one instance out of many, of the effect produced upon the tide when it has to pass along a narrow channel, and to overcome an opposing current.

The explanation that has been given

---

* We have already shown, that it is high water at any place twice in every 24 hours 50½ minutes. When a place is on the *same side* of the equator as the moon, the tide, which is produced while the moon is *above* the horizon of the place, will *exceed* the tide which is produced while the moon is *under* the horizon of the place; but when a place is on the opposite side of the equator to the moon, the effect is exactly the reverse. This is explained in the following way;—LK (fig. 3) is a parallel of north, and MN a parallel of south, latitude; CHFA is a meridian; and when the moon is at K, LK and MN are also circles of the highest tides. Each place under those circles has high water twice in 24 hours 50½ minutes—once, when it is under L or M—and again, when it is under K or N; but, under M and N, the *tides are not so high* as at L and M, because we have before shown that L and M are the points of the highest tides when the moon is at p. Now, to places under L and N, the moon is *above* the horizon—and, to places under M and K, she is *below* the horizon; and, therefore, when the moon is at p, *north* of the equator, a place under LK, a parallel of *north* latitude, will have its *greatest high water* when the moon is *above* the horizon; but a place under MN, a parallel of *south* latitude, will have its *greatest high water* when the moon is *below* the horizon. When the moon is at p′, *south* of the equator, these effects will be just reversed. In summer, when the sun's declination is considerably north, the afternoon tides, *north* of the equator, are higher than the morning tides; in winter, the morning tides exceed those of the afternoon.

of the manner in which tides are created in the ocean, will enable us to perceive why it is that, in some gulfs and inland seas, there are either no tides, or such trifling ones as to be scarcely discernible. In figure 1, the waters at A are brought to B, not only by the moon raising up the parts immediately under her, but also by her drawing obliquely towards B the parts distant from B, and by the lateral flowing of the neighbouring waters (*p n*, for instance) towards B, which results from their being less attracted by the moon, and, therefore, heavier than those at B. Being heavier than B, they press upon and flow towards that part. In small collections of water, the moon acts with the same line of attraction, or nearly so, upon every portion of the surface at once, and, therefore, the whole of the waters being equally elevated at the same period, no part of them is ever higher than the other. This is one reason why the Baltic has no perceptible tides, and why even those of the Mediterranean are hardly visible.* But in addition to this, the two seas in question are so circumstanced that they cannot receive tides from the Atlantic: 1st, because their entrances are not turned towards the main direction of the Atlantic tide; 2ndly, because their entrances are so narrow, that the quantity of tide which that ocean can, in a few hours, impel into them, is insufficient, after being spread over the extensive surfaces of the two seas, to raise their level at all perceptibly. The Greeks, who accompanied Alexander the Great in his expedition to the east, having never been on any other coasts than those of the Mediterranean, were seized with complete consternation on first beholding the retreat of the strong tide which the Indian ocean sends into the river Indus. In gulfs which are differently circumstanced with respect to the direction of their entrances, and which have openings wider, as compared with their extent, the tides propagated from the ocean are sensibly felt. Hudson's and Baffin's Bays, and the Red Sea, are examples which prove the correctness of this observation.

Currents and winds (especially the latter) have, according to their direction, an influence either in quickening or retarding the tide; indeed a powerful wind will sometimes keep a tide out of very narrow channels. On the contrary, a strong wind coming from the same quarter as the tide, will raise it several feet above its usual level.

The causes which render the movements of the tides complex and irregular, may thus be summed up under four heads—1. The variations in the positions of the sun and moon, with respect to the equator and to each other. 2. The obstacles presented by the land; 3. by winds; and 4. by currents. The existence of these causes renders it impossible to lay down any general rule for calculating the level, either of high or of low water, in different latitudes.

3. *Currents* in the ocean may be occasioned in various ways: they may arise from an external impulse, (a gale of wind for instance); from a difference in temperature or saltness between two parts of the sea; from the periodical melting of the polar ice, or from the inequality of the evaporation which the surface of the sea undergoes in different latitudes. These causes may produce either constant or occasional currents, and, according as they act in concert or in opposition, will their effects be various.

The most remarkable currents are those which continually follow the same direction. There is one which sets regularly from each of the poles towards the equator; and when we get within twenty-eight or thirty degrees of the line on either side, a general movement is observed in the ocean, in a direction nearly from east to west. The existence of the two polar currents is proved by the floating of masses of ice from the frigid into the temperate regions; these masses are, at times, seen as low as the forty-fifth, or even the fortieth degree of latitude. It was the opposition of the polar current which principally occasioned the failure of the attempt made last year under Captain Parry to reach the north pole; before they desisted from their efforts, the expedition found that, as they advanced over the ice, they were being drifted *southward*, at a rate faster than that at which they were travelling northward. It is equally certain that a tropical current exists, judging not only from the direction of bodies floating on the water, but also from the circumstance that vessels, in crossing from

---

* The little tide which there is in the Mediterranean, seems to be formed chiefly in the part extending to the east of Malta, and to proceed northward into the Gulf of Venice. M. D'Angos observed that at Toulon, on the coast of France, the sea rose a foot about three hours and a half after the moon passed the meridian.

Europe to America, descend to the latitude of the Canary Islands, where they fall into a current and are carried rapidly to the west. In going from America to Asia across the Pacific, a similar effect is observed. It might be supposed that this was due solely to the trade-winds, but such is not the case: for it is quite possible to distinguish their effect from that of the currents, since the progress of the vessel is quicker than it could be with the aid of the wind alone.

The origin of the polar currents is, no doubt, in a great measure, to be referred to the centrifugal force which is the result of the earth's rotation. *(See Mathematical Geography*, chap. 8.) It may be further explained, when we reflect that the water towards the poles, both on account of its lower temperature and its being less attracted by the heavenly bodies, is *heavier* than the water in the tropical regions, and, moreover, that the heat of the torrid zone occasions a much more powerful evaporation of the sea than is elsewhere experienced: the consequence is, that the waters nearer the poles will move towards the equator, in order to restore the equilibrium which has, in these several ways, been destroyed. The tropical current may also, though in another manner, be explained as proceeding from the earth's rotation. The waters, as they advance from the polar seas, pass from regions where the rotatory motion of the earth's surface is very slight, to those where it is exceedingly rapid; they cannot immediately acquire the rapid motion with which the solid parts of the earth revolve in the tropical regions, and they are, accordingly, left rather behind, that is, to the *westward* (the earth turning round from west to east). The ocean, consequently, appears to retreat from the western, and advance upon the eastern coasts of the continents, or, in other words, to have a general movement from east to west; and the effect is very much assisted by the constant blowing of the trade winds.

We will now explain the modifications or changes which this grand movement in the ocean undergoes, in consequence of the obstacles presented by the land to its free progress. When it meets with shores or narrow straits to impede or turn aside its course, it forms strong and even dangerous currents. The eastern coast of America, and the West India Islands, constitute a sort of dyke to the general westward motion of the Atlantic; and it will be seen, if we refer to a map, that from Cape St. Roche, which has about five degrees of south latitude, the coast of South America stretches away in a continued line to the north-west, as far as the isle of Trinidad. Owing to this shape of the coast, the waters, as far as the tenth degree of south latitude, are, when they approach America, carried away in a current to the north-west. This current afterwards enters the gulf of Mexico, through the strait formed by the western end of Cuba, and the opposite peninsula, (from this part it is called, by navigators, the *Gulf-stream,*) and follows the bendings of the Mexican coast, from Vera Cruz to the mouth of the Rio del Norte, and thence to the mouths of the Mississippi, and the shoals west of the southern extremity of Florida. It next takes a new direction to the north, and rushes impetuously into the gulf of Florida. M. Humboldt observed in the month of May 1804, in the 26th and 27th degrees of latitude, that its velocity was eighty miles in twenty-four hours, although, at the time, there was a violent wind against it. At the end of the gulf of Florida, (north lat. 28°) it runs to the north-east, at the rate, sometimes, of five miles an hour. It may always be distinguished by the high temperature[*] and the saltness of its waters, their indigo-blue colour, and the quantity of sea-weed floating on the surface, and also by the heat of the surrounding atmosphere. The rapidity and temperature of the *Gulf-stream*, diminish towards the north, while, at the same time, its breadth increases.[†] Its further progress northward is at last checked by the southern extremity of the great bank of Newfoundland, in the 42d degree of latitude, where it turns suddenly to the east. It afterwards continues moving towards the east, and the east-south-east, as far as the Azores islands; and thence it turns towards the straits of Gibraltar, the Isle of Madeira, and the group of the Canaries, till, on reaching the parallel of Cape Blanco, it completes the round by mixing with the grand westerly current of the tropics. It is probable, however, that a branch still keeps on its course to the south and south-east, along the coast of Africa; for it is well known that ships, if they approach too near the shore, are drawn into the gulf of Guinea, and with difficulty get out again. We thus see that between the parallels of 11 and 43 degrees, the waters of the Atlantic are carried on in a continual whirlpool. Humboldt remarks that, supposing a particle of water to return to the same place from which it departed, "we can estimate, from our present knowledge of the swiftness of currents, that this circuit of three thousand eight hundred leagues is not terminated in less than two years and ten months. A boat, which may be supposed to receive no impulse from the winds, would require thirteen months, from the Canary Islands, to reach the coast of Caraccas; ten months to make the tour of the Gulf of Mexico and reach Tortoise Shoals, opposite the port of the Havannah; while forty or fifty days might be sufficient to carry it from the straits of Florida to the bank of Newfoundland. It would be difficult to fix the rapidity of the retrograde current from this bank to the coasts of Africa: estimating the mean velocity of the waters at seven or eight miles in twenty-four hours, we find ten or eleven months for this last distance." It is a curious fact, that towards the close of the 15th century, before Europeans were acquainted with the existence of America, two bodies belonging to an unknown race of men were cast by the Gulf-stream on the coasts of the Azores, and pieces of bamboo were brought by the same current to the shore of the small island of Porto Santo; by these circumstances, Columbus is said to have been strengthened in his conjectures with respect to the existence of a western continent.

---

[*] Humboldt observes that "the waters of the Mexican Gulf, forcibly drawn to the north-east, preserve their warm temperature to such a point, that at forty and forty-one degrees of latitude, he found them at seventy-two degrees and a half (Fahrenheit); when, out of the current, the heat of the ocean at its surface was scarcely sixty-three degrees and a half. In the parallel of New York, (forty-one degrees north) the temperature of the *Gulf-stream* is, consequently, equal to that of the seas of the tropics in the eighteenth degree of latitude."

[†] Its breadth in latitude twenty-eight degrees and a half is seventeen leagues; (3.46 miles to a league) in the parallel of Charles town, (thirty-three degrees, nearly) from forty to fifty leagues; and on the meridian of Corvo and Flores, the westernmost of the Azores islands, it is one hundred and sixty leagues.

An arm of the Gulf-stream in the 45th and 50th degrees of latitude, runs to the north-east, towards the coasts of Europe, and becomes very strong when the wind has blown long from the west. The fruit of trees which belong to the American torrid zone is every year deposited on the western coasts of Ireland and Norway; and on the shores of the Hebrides are collected seeds of several plants, the growth of Jamaica, Cuba, and the neighbouring continent. The most striking circumstance, perhaps, is that of the wreck of an English vessel, burnt near Jamaica, having been found on the coast of Scotland.

There are various currents in the Pacific and Indian oceans. The general westward motion of the former is impeded by a numerous archipelago, and hence it receives different directions. A strong currrent sets to the west, through each of the two straits which respectively separate New Holland from New Guinea and from Van Diemen's Land. It then gets diverted, and flows northward along the coast of Sumatra, till it reaches the bottom of the Bay of Bengal. The following appears to be the reason of its taking this course:—the general impetus of the Pacific towards the west, being encountered by New Holland and the numerous East India Isles, is broken and dispersed; while the westerly motion of the Indian sea has not, in so early a stage, acquired much strength; the polar current from the south, at the same time, presses upon the wide opening which the Indian sea presents to that quarter, and the waters on the eastern verge of that sea are, therefore, pushed into the Bay of Bengal. In the neighbourhood of Ceylon and the Maldive islands, however, the tropical motion has become powerful enough to resist the polar current. The westerly current then recommences, but is again turned out of its line and made to flow to the south-west, by the chain of islands and shallows, which reaches from the extremity of the Indian peninsula to Madagascar. After passing Madagascar, it dashes against Africa, and at the termination of that continent, mingles with the general motion of the waters.

A current afterwards sweeps from the Atlantic into the Pacific ocean, through the straits of Magellan. There can be little doubt that this is a branch of the general current from the south pole; though, at the same time, it may be partly the result of the westerly movement of the Atlantic, which, being checked by the shores of Brazil, flows to the south-west, along the South American coast.

There is a question connected with the currents of the Arctic ocean, which has engaged a good deal of attention, and been considered difficult to explain;

it is from what quarters the timber can come which is found floating on the polar seas in such large quantities, and so much of which is thrown ashore on the northern side of Iceland*. The few specimens seen of the growth of Mexico and Brazil, must have travelled to the north by means of the Gulf-stream of which we have spoken; the rest (principally pines and firs) most likely comes from Siberia and North America, along the shores of which it is drifted till it arrives at the opening into the Atlantic, in the midst of which Iceland is placed.

The existence of *under currents* different from, and even opposite in their direction to those on the surface is, by no means, improbable in some cases, though it is a matter not admitting of proof. It has been thought that the Mediterranean, which has a strong flow always setting into it through the straits of Gibraltar, sends back a portion of its waters into the Atlantic, by a concealed current. Contrary currents, passing along side by side, are not uncommon. In the Kattegat, a northern current flows out of the Baltic, along the coast of Sweden, while a southern one enters the Baltic along the coast of Denmark. When two opposite currents of about equal force meet one another, they sometimes, especially in narrow channels, turn upon a centre and assume a spiral form, giving rise to *eddies* or *whirlpools*. The most celebrated of these are the *Euripus*, near the island of Eubœa, in the Grecian Archipelago; *Charybdis*, in the strait between Italy and Sicily; and the *Maelstrom*, off the coast of Norway. The most violent of them, when agitated by tides or winds, become very dangerous to navigation.

On Currents in the Atmosphere.

It does not belong to our present subject to investigate the properties and component parts of the atmosphere, but it will be proper to notice the agitations or movements which are constantly taking place in that fluid. A change in the temperature of a portion of air; an increase or a diminution of the quantity of water which it holds in a state of vapour; in short, any circumstance which causes it either to contract or to expand, destroys the equilibrium subsisting among the different parts of the atmosphere, and occasions a rush of air, that is, a *wind*, towards the spot where the balance has been destroyed.

Every one knows that the velocity and force of winds are exceedingly various; accordingly, several methods have been suggested, and instruments invented, in order to determine their amount with some degree of exactness. In the fifty-first volume of the "Philosophical Transactions," there is a table of the different velocities and forces of winds, drawn up from a considerable number of facts and experiments; the following particulars are extracted from it:—

Velocity of the Wind.	Perpendicular force on one square foot, in Avoirdupois pounds.	Common Appellations of the forces of such Winds.
Miles in an hour.	dec. parts.	
1	.005	Hardly perceptible.
4	.079	Gentle, pleasant wind.
5	.123	
10	.492	Brisk gale.
15	1.107	
30	4.429	High wind.
35	6.027	
50	12.300	A storm.
80	31.490	A hurricane.
100	49.200	

Winds may be divided into three classes—those which flow *constantly* in the same direction, those which are *periodical*, and those which are variable. It must be observed that the terms which express the direction of winds are employed in a sense quite contrary to that in which they are used when we speak of the direction of currents in the ocean; a westerly current, for example, signifies a current flowing *towards* the west, but a westerly wind signifies a wind coming *from* that quarter.

The *permanent* winds are those which blow constantly between, and a few degrees beyond, the tropics, and are called *trade-winds*. On the north of the equator, their direction is from the north-east (varying at times a point or two of the compass each way); on the south of the equator, they proceed from the south-east. The origin of them is this:—the powerful heat of the torrid zone rarefies or makes lighter the air of that region; the air, in consequence of this rarefaction, rises, and to supply its place a colder atmosphere from each of the temperate zones moves towards the equator. But (as in the case of the polar currents in the ocean) these north and south winds pass from regions, where the rotatory motion of the earth's surface is less, to those where it is greater. Unable at once to acquire this new velocity, they are left behind, and instead of being north and south winds, as they would if the earth's surface did not turn round, they become *north-east* and *south-east* winds. The space included between the second and fifth degrees of north latitude, is the *internal boundary* of the two winds; and this space experiences calms, frequently interrupted, however, by violent storms. The reason why it is situated to the north of, instead of exactly at, the equator, seems to be that the northern hemisphere is warmer than the southern; for since the trade-winds are the result of the continual ascent of heated air in the equatorial parts, their internal boundary will be where the principal ascent is going on,—that is, where the annual temperature is the highest; which, on account of the above-mentioned inequality of temperature in the two hemispheres, will not be at the equator, but somewhat to the north of it. The *external limits* of the trade-winds are at a medium in about the 30th degrees of north and south latitude respectively; but each limit, as the sun approaches the neighbouring tropic, declines further from the equator. The position of the sun has an influence also on their strength and direction; for when that luminary is near the tropic of Cancer, the south-east wind becomes gradually more southerly, and stronger, and the north-east weaker, and more easterly; the effect is reversed when he gets towards the tropic of Capricorn.

---

* From the account which Captain Parry has given of his last voyage, it appears that there is also a great quantity of timber which has been cast by the sea upon the northern coast of Spitzbergen.

The trade-winds would blow regularly round the whole globe within the distance of about 30 or 40 degrees from the equator each way, if the space within those limits were all covered with water; but the uneven surface and unequal temperature of the land divert and derange them: it is on this account that the trade-winds are constantly experienced only over the open ocean. The larger the expanse of ocean over which they range, the more steadily they blow: thus in the Pacific they are commonly more steady than in the Atlantic ocean, and in the south than in the north Atlantic. In sailing from the Canaries to Cumana, on the north coast of South America, it is hardly ever requisite to touch the sails of the vessel. The voyage across the Pacific from Acapulco on the west coast of Mexico, to the Philippine islands, is performed with equal facility; and if there were a channel through the isthmus of Panama, a westward passage from Europe to China would be more speedy and safe than the usual navigation thither round the Cape of Good Hope; the only interruption to the evenness of this voyage would be in the Caribbean Sea and the Gulf of Mexico, where the trade wind blows impetuously, and is sometimes interrupted by westerly winds. It would not be possible, however, to return by the same route, because in sailing east way must be made to the northward, in order to get beyond the region of the trade into that of the variable winds. Both in the Atlantic and in the Pacific Ocean, the current of the trade-winds becomes broader and more directly east in its course, as it advances from one side to the other of those extensive basins. On the west coast of Africa, owing to the rarefaction which the air undergoes over that continent, the wind is mostly turned towards the shore; from Cape Bojador to Cape Verd it is generally north-west, and thence to the island of St. Thomas, under the equator, it bends gradually first to the west and then to the south-west. Along the coasts of Chili and Peru a south wind prevails. These are two instances of the interruption which the trade-winds experience in the neighbourhood of large masses of land.

In the Indian Ocean the south-east trade-wind prevails between 28° and 10° of south latitude, from within a few degrees of the east side of Madagascar, nearly to the coast of New Holland; but from the 10th degree of south latitude to the northern shores of that ocean, the uniformity of the tropical movements of the atmosphere is destroyed by the *monsoons*[*], which belong to the class of *periodical* winds. These blow half the year from one quarter, and the other half from the opposite direction: when they shift, variable winds and violent storms prevail for a time, which render it dangerous to put to sea. They of course suffer partial changes in particular places, owing to the form and position of the lands, and to other circumstances, but it will be sufficient to give their general limits and directions. Northward from the third degree of north latitude, a *south-west* wind blows from April to October—from October to April a *north-east;* these monsoons extend over the China sea, but here they incline more to the direction of north and south. Between the 3d and 10th degrees of south latitude, a *north-west* wind blows from October to April, and a *south-east* during the other six months of the year: the former is seldom steady in the open sea, but in December and January it sometimes extends northwards a degree or two beyond the equator. These two monsoons have the greatest strength and regularity in the Java Sea, and thence eastward towards New Guinea. The facts above exhibited may be thus summed up:—from April to October a *south-west* wind prevails north of the equator, southward of this a *south-east* wind—from October to April, a *north-east* wind north of the equator, and a *north-west* between the equator and 10° of south latitude; south of this the usual trade wind, which is in motion through the whole year.

In attempting to account for these movements of the atmosphere over the Indian Ocean, the first thing which strikes us is, that the north-east and south-east monsoons, which are found the one on the north and the other on the south side of the equator, are nothing more than the trade-winds blowing for six months, and then succeeded for the remainder of the year by winds directly opposite. It is also to be noticed that the south-west monsoon in the northern, and the north-west monsoon in the southern hemisphere, each prevails while the sun is perpendicular to their respective regions: they are, therefore, connected with the immediate presence of that luminary. If the Indian Ocean were not bounded as it is by land on the north, the trade-winds would blow over it (at least in the central parts) as they do in the Atlantic and Pacific Oceans. But it is well known that water, owing to its transparency, is very little warmed by the sun's rays, whereas the land is powerfully heated by them; consequently, when the sun is between the equator and the tropic of Cancer, India, Siam, and the adjacent countries, become much hotter than the ocean; the air over them gets rarefied and ascends; colder air then rushes in from the Indian ocean, and a *south-west* wind is produced. When the sun, however, has crossed to the south of the equator, these countries become gradually cool, and the north-east trade-wind resumes its course. At the same time the *north-west* monsoon commences in the southern hemisphere, in consequence of the air over New Holland being rarefied by the presence of the sun.

The monsoons in the Red Sea blow in the direction of the shores; and a similar effect is observed in the Mozambique channel, between Africa and Madagascar, where these winds follow the line of the channel. On the coast of Brazil, between Cape St. Augustine and the island of St. Catharine, and in the bay of Panama, on the west of the isthmus of that name, periodical winds occur somewhat similar to the monsoons of Asia.

The *land* and *sea-breezes*, which are common on coasts and islands situated between the tropics, are another kind of periodical winds. During the day, the air, over the land, is strongly heated by the sun, and a cool breeze sets in from the sea; but in the night the atmosphere over the land gets cooled, while the sea, and consequently the air over it, retains a temperature nearly even at all times: accordingly, after sunset, a land-breeze blows off the shore. The sea-breeze generally sets in about ten in the forenoon, and lasts till six in the evening; at seven the land breeze begins, and continues till eight in the morning, when it dies away. These alternate breezes are, perhaps, felt more powerfully on the coast of Malabar than anywhere—their effect there extends to a distance of twenty leagues from the land. During summer, the *sea-breeze* is very perceptible on the coasts of the Mediterranean, and sometimes even as far north as Norway.

---

[*] From the Malay word *moossin*, which signifies a *season*.

WORKS PUBLISHED BY BALDWIN AND CRADOCK.

Geography and Astronomy.

GUY'S School Geography on a new, easy, and highly improved Plan; comprising not only a complete general Description, but much Topographical Information, in a well-digested Order, exhibiting *Three* distinct Parts, and yet forming *One* connected Whole expressly adapted to every class of Learners, both in Ladies' and Gentlemen's Schools. 10th Edition, corrected and enlarged. With 7 Maps, 3s. in red.

A Geographical Key to the Problems and Questions in Guy's Geography. 1s. 6d. sewed.

Introduction to Geography and Astronomy, by the Use of the Globes and Maps, and a Table of Latitudes and Longitudes. By E. and J. BRUCE, Teachers of Geography and Mathematics. The 7th Edition, with very considerable Improvements. 7s. 6d. bound.

Key to this Work, with answers to all the Problems. 2s. 6d. sewed.

A System of Modern and Ancient Geography; with a Series of Geographical Examinations. By JOHN HOLLAND, of Manchester. The 6th Edition, very much improved, with a new Map of Canals and Rivers, and a Map of the Ancient World. In 12mo. 4s. bound.

Bryan's (Mrs.) Comprehensive Astronomical and Geographical Class-Book, for the Use of Schools and Private Families. 8vo with Plates. 7s. 6d. boards. Key to the same 1s.

An Introduction to the Use of the Globes; containing Definitions and Problems in Geometry; the Stereographic Projection of the Sphere; and the Rise and Progress of Geography and Astronomy. By JOHN GREIG. The 3d Edition, 12mo. 3s. 6d. bound.

Elements of Astronomy, with 18 excellent Engravings, familiarly illustrating all the prominent and interesting Parts that are within the Comprehension of Young Persons; to which is added a complete Set of Questions for Examination. Designed for senior Scholars of both Sexes, for private Students, and for the Use of Families generally. By JOSEPH GUY, formerly of the Royal Military College, Great Marlow. The 3d Edition much improved and handsomely printed, 5s. 6d.

Atlases and Geographical Charts.

Ostell's New General Atlas, including Maps of Canaan or Judea, ancient Greece, and the Roman Empire. A new Edition on an entirely new set of Plates, engraved on an enlarged Scale, and corrected from the latest and best Authorities, including the Discoveries of Denman and Clapperton, Captain Parry, &c. Containing 30 Maps in royal 4to. coloured outlines, 18s. half-bound; or with the Maps full coloured, one guinea.

N. B. The same work on a fine imperial drawing paper, full-coloured and handsomely bound for the Library Table. 1l. 7s.

Russell's New Atlas of Modern Geography, with a Map of Judea for Scripture reading. Finely engraved on 25 Plates with coloured Outlines. 8vo. 12s. neatly half-bound.

The Bible Atlas; or, Sacred Geography Delineated, in a complete Series of Scriptural Maps, drawn from the latest and best Authorities, and engraved by R. PALMER. On 26 small 4to. Plates, 16s. coloured, or 12s. plain, neatly half bound.

A New Map of Palestine, (compiled from original Sources,) with the adjacent Countries; showing their Ancient and present Political Divisions, &c. and the Routes of various Travellers. By RICHARD PALMER. Size 38 inches by 25.

Thomson's New General Atlas; containing 80 Maps, full coloured, size 24 inches by 20, on imperial folio, engraved by the first Astists, from Drawings made on purpose; also, a Memoir of the Progress of Geography; a Chapter on Physical Geography; a View of the Comparative Heights of Mountains and Lengths of Rivers; and a consulting Index. Strongly half bound in Russia leather, 11l. 11s.

*** This work is always kept up to the latest discoveries; and the present edition has two additonal maps, including New South Wales and Van Diemen's Land; also the Discoveries of Captains Ross, Franklin, and Parry, to the latest period.

Wilkinson's Geography Epitomised, exemplifying all the terms used in Geography, including the Lines in Use on the Sphere. large 4to. on 18 Copper Plates, 12s. boards, coloured, 15s.

A Geographical Synopsis of the World, and Topographical View of Great Britain and Ireland; exhibiting the Extent and grand Divisions of the World, with other important Information. By T. OLIVER. On a sheet of Columbier paper, 7s. coloured in divisions; on canvass and roller, 10s. 6d.; and varnished, 14s.

Navigation and Nautical Astronomy.

A Treatise on Navigation, and Nautical Astronomy, adapted to Practice, and to the Purposes of Elementary Instruction; containing the Elementary Principles of Algebra, Geometry, Plane and Spherical Trigonometry, and Navigation; the Method of keeping a Sea Journal; Concise and Simple Rules, with their investigations, for finding the Latitude and Longitude, and the Variations of the Compass, by Celestial Observations; the Solution of other useful Nautical Problems with an extensive Series of Examples for Exercise, and all the Tables requisite in Nautical Computations. By EDWARD RIDDLE, Master of the Mathematical School, Royal Naval Asylum, Greenwich. In 8vo. 11s. boards, or 12s. bound.

The Young Navigator's Guide to the Sidereal and Planetary parts of Nautical Astronomy, being the Theory and Practice of finding the Latitude, the Longitude, and the Variation of the Compass by the Fixed Stars and Planets; to which is prefixed the Description and Use of the New Celestial Planisphere. By THOMAS KERIGAN, R. N. with a newly constructed Planisphere of the Starry Heavens, on a very large scale. In royal 8vo. 2d Edition reduced in price to 14s. boards.

A Practical Introduction to Spherics and Nautical Astronomy. By P. KELLY, LL.D., Master of the Finsbury-square Academy. 4th Edition, in royal 8vo. 12s. boards.

Chronology, History, and Biography.

An Historical and Biographical Atlas; or, Charts of Sacred and Profane History and Biography for the Use of Schools and Students in History, from the Creation of the World to the Birth of Christ. By JOHN BRUCE, In small folio; the Charts beautifully engraved by BARRIFF, and printed on Drawing paper, price 16s. handsomely half-bound and lettered.

A Summary of General History, from the Creation to the Birth of Christ; with Questions for Examination in each Portion of History. By the Same. Published as a Companion to the Historical and Biographical Atlas. In 8vo. Price 3s. 6d. canvas boards.

Sketches of the Domestic Manners and Institutions of the Romans. 2d Edition, considerably enlarged and newly arranged 12mo. 7s. boards.

*** Carefully and judiciously compiled from a variety of the best sources, there are few books of the kind which we could recommend to be put into the hands of young persons with greater satisfaction than this little volume."—*Lit. Gazette.*

Elton's History of the Roman Emperors, from the Accession of Augustus to the Fall of the last Constantine. In seven Books. Ornamented with Portraits of the Roman Emperors, and Maps, 7s. 6d. half-bound.

Essays on the Institutions, Government, and Manners of the States of Ancient Greece. By HENRY DAVID HILL, D.D. Professor of Greek in the University of St. Andrew's. 2d Edition 12mo. 7s. boards.

*** "To young persons who are just entering upon the higher classics, and to studious men who are desirous of repairing by their own industry, the accidental defects of an imperfect education, a more useful assistant cannot, we think, well be furnished."—*Quarterly Review.*

A Compendious View of Universal History and Literature, in a Series of Tables from the German of PROFESSOR BREDOW; with an appended Table of Painters, from the French Notes of SIR MATTHEW VAN BREE. By MAJOR BELL. 2d Edition, enlarged and improved, royal folio, 1l. 10s. handsomely and strongly half-bound.

*** The CHART OF PAINTERS, arranged according to Schools and Ages, may be had separately, 12s. coloured and framed, or 7s. 6d. in the sheet plain.

Priestley's (Dr.) Chart of History, containing a View of the Principal Revolutions of Empires that have taken place in the World. The 15th Edition, corrected and brought down to the Close of the Eighteenth Century; with a Description, 10s. 6d.; or on canvass and Rollers, 16s.

Priestley's (Dr.) Chart of Biography. A New Edition, brought down to the Close of the Eighteenth Century; with a Description. 10s. 6d., or on canvass and rollers, 16s.

Guy's Chart of General History, Ancient and Modern; on a large sheet of Columbier drawing paper. The 3d Edition, corrected, 7s. coloured; on canvass and rollers, 10s. 6d.; and varnished, 14s.

*** A chart of this kind will greatly facilitate the student's progress, and give him clearer ideas of the rise, duration, and fall of each kingdom and empire, than the bare perusal of many volumes.

Tables of Comparative Chronology, exhibiting the Dates of the principal Events which took place from the Flood to the Fall of the Roman Empire. By A. PICQUOT. In 12 engraved Charts, and with a fine Vignette Title. Imperial 4to. 12s. boards.

LIBRARY OF USEFUL KNOWLEDGE.

PHYSICAL GEOGRAPHY.

PART II.

PUBLISHED UNDER THE SUPERINTENDENCE OF THE SOCIETY FOR THE DIFFUSION OF USEFUL KNOWLEDGE.

COMMITTEE.

Chairman—H BROUGHAM, Esq., F.R.S., M.P. *Vice Chairman*—LORD JOHN RUSSELL, M.P.
Treasurer—WILLIAM TOOKE, Esq., F.R.S., V.P. Soc. Arts.

Rt.Hon.J.Abercrombie, M.P.
W. Allen, Esq., F.R.S.
Lord Althorp, M.P.
Rt. Hon. Lord Auckland.
Capt.F.Beaufort, R.N., F.R.S.
C. Bell, Esq. F.R.S., L. & E.
T. F. Buxton, Esq., M.P., F.R.S.
R. Otway Cave, Esq., M.P.
John Conolly, M.D.
William Coulson, Esq.
Wm. Crawford, Esq.
Fred. Daniell, Esq., F.R.S.
T. Denman, Esq.
Hon. G. Agar Ellis, M.A., M.P.
T. F. Ellis, Esq., M.A.
I. L. Goldsmid, Esq., F.R.S.
B. Gompertz, Esq., F R.S.
H.Hallam, Esq., F.R.S., M.A.
M. D. Hill, Esq.
Rowland Hill, Esq.
E. Hill, Esq.
Leonard Horner, Esq., F.R.S.
David Jardine, Esq.
Henry B. Ker, Esq., F.R.S.
J. G. S. Lefevre, Esq., F.R S.
Edward Lloyd, Esq., M.A.
James Loch, Esq., M.P., F.G.S.
J. W. Lubbock, Esq.
Dr. Lushington, D.C.L., M.P.
Sir J. Mackintosh, M.P., F.R.S.
B. H. Malkin, Esq., M.A.
Rev. Ed. Maltby, D.D., F.R.S.
James Manning, Esq.
F. O. Martin, Esq.
J. Marshall, Esq., M.P.
John Herman Merivale, Esq.
James Mill, Esq.
James Morrison, Esq.
Rt. Hon. Lord Nugent, M.P.
Sir H. Parnell, Bart., M.P.
Professor Pattison.
T. Spring Rice, Esq., M.P., F.A.S.
Dr. Roget, Sec. R.S.
C. E. Rumbold, Esq., M.P.
J. Smith, Esq., M.P.
Wm. Sturch, Esq.
Rt. Hon. Lord Suffield.
Dr. A. T. Thomson, F.L.S.
William Eyton Tooke, Esq.
A. N. Vigors, Esq., F.R.S.
H. Warburton, Esq., M.P., F.R.S.
H. Waymouth, Esq.
J. Whishaw, Esq., M.A., F.R.S.
Mr. Serjeant Wilde.
John Wrottesley, Esq., M.A.

Birmingham Local Association.
Rev. John Currie, *Chairman.*
Paul Moon James, Esq., *Treasurer.*
Thos. Clarke, Esq.
T. Eyre Lee, Esq. } *Hon. Secs.*
Jos. Parkes, Esq.
Bristol—J. N. Sanders, Esq, *Chairman.*
J. Reynolds, Esq., *Treas.*
J. B. Estlin, Esq., *Sec.*
Cambridge—Rev. James Bowstead, M.A.
Rev. Prof. Henslow, M.A., F.L.S. & G.S.
Rev. Leonard Jenyns, M.A., F.L.S.
Rev. John Lodge, M.A.
Henry Malden, Esq., M.A.
Fred. Malkin, Esq., M.A.
Rev. Geo. Peacock, M.A., F.R.S. & G.S.
Marmaduke Ramsay, Esq., M.A., F.L.S.
Rev. Prof. Sedgwick, M.A., F.R.S. & G.S.
Professor Smyth, M.A.
Rev. Connop Thirlwall, M.A.
Derby—Joseph Strutt, Esq.
Devonport—Charles Greaves, Esq.
Dublin—Hon. Thos. Vesey.
Edinburgh—R. Greville, LL.D.
D. Ellis, Esq., F.R.S.
Capt. Basil Hall, R.N., F.R.S.L. & E.
Fras. Jeffrey, Esq.
Prof. Napier, F.R.S.E.
Rev. A. Thomson, D.D.
W. Thomson, Esq.
Etruria—Jos. Wedgwood, Esq.
Exeter—Rev. J. P. Jones.
J. Tyrrell, Esq.
Glasgow—K. Finlay, Esq.
D. Bannatyne, Esq.
Rt. Grahame, Esq.
Professor Mylne.
Alexander McGrigor, Esq.
Charles Macintosh, Esq. F.R.S.
Hull—Dl. Sykes, Esq., M.P.
Launceston—Rev. J. Barfitt.
Leeds—Benjamin Gott, Esq.
J. Marshall, Jun., Esq.
Lewes—J. W. Woollgar, Esq.
Liverpool Local Association.
Dr. Traill, *Chairman.*
J. Mulleneux, Esq., *Treas.*
Rev. W. Shepherd.
J. Ashton Yates, Esq.
Maidenhead—R. Goolden, Esq., F.L.S.
Manchester Local Association.
G. W. Wood, Esq., *Chairm.*
Benjamin Heywood, Esq., *Treas.*
T. W. Winstanley, Esq., *Hon. Sec.*
Sir George Phillips, Bart., M.P.
Newcastle—James Losh, Esq.
Rev. W. Turner.
Newport—Ab. Clarke, Esq.
T. Cooke, Jun., Esq.
R. G. Kirkpatrick, Esq.
Newport Pagnell—James Millar, Esq.
Plymouth—Geo. Harvey, Esq., F.R.S.
Portsmouth—E. Carter, Esq.
G. Grant, Esq.
D. Howard, Esq.
Rev. Dr. Inman, Nav. Col.
Sheffield—J. H. Abraham, Esq.
Waterford—Sir John Newport, Bart., M.P.
Wolverhampton—J. Pearson, Esq.

THOMAS COATES, *Secretary.*

*** All communications to the Society to be addressed to Mr. Coates, No. 4, Holborn Court, Gray's Inn; and, *if from the Country*, under cover to any of the Committee who may be in Parliament.

LONDON:—1829.
BALDWIN AND CRADOCK;
OLIVER AND BOYD, EDINBURGH; ROBERTSON AND ATKINSON, GLASGOW;
W. F. WAKEMAN, DUBLIN; AND G. AND C. CARVILL, NEW YORK.

(17.) *April* 1. [*Price Sixpence.*

3

ERRATA—PHYSICAL GEOGRAPHY, PART I.

Page 3, col. 1, l. 14 from the bottom, for *of*, read *on*.
„ 26, „ 2, l. 3 from top, for *K*, read *p*.
„ 26, „ 2, l. 7 „ „ for *M*, read *K*.

UNDER THE SUPERINTENDENCE OF THE SOCIETY FOR THE DIFFUSION OF USEFUL KNOWLEDGE.

THE PUBLICATION of the LIBRARY of ENTERTAINING KNOWLEDGE COMMENCED on the 31st MARCH, when the first *half-volume* of the Series appeared. The Library will be formed by the publication of a similar half-volume on the first day of every month, so that a regular delivery throughout the country may take place at the same time as the Magazines. The half-volume will consist of about 200 pages, of a size adapted both to the Library and the Pocket; and, in subjects where Illustrations are required, it will be embellished with wood engravings.

The Price of each Half-Volume or Monthly Part will be Two SHILLINGS; but, for the convenience of those who prefer a weekly purchase of this Series, the half-volume will be subdivided into four Numbers, one of which will be issued every Saturday (after the publication of the half-volume) price SIXPENCE. The Series commenced with the following work:

THE MENAGERIES; OR, QUADRUPEDS,

DESCRIBED AND DRAWN FROM LIVING SUBJECTS.

London: CHARLES KNIGHT, Pall-Mall East;
Longman and Co., Paternoster Row; Oliver and Boyd, Edinburgh, Robertson and Atkinson, Glasgow; W. F. Wakeman, Dublin; E. Willmer, Liverpool;
and G. and C. Carvill, New York.

TREATISES published to APRIL 1st, 1829.

The Objects, Advantages, and Pleasures of Science.—Preliminary Treatise.
1 Hydrostatics.
2 Hydraulics.
3 Pneumatics.
4 Heat—Part 1.
5 —— Part 2.
6 Mechanics—First Treatise on Prime Movers.
7 ———— Second Treatise, on the Elements of Machinery.
8 ———— The same Subject—Part 2.
9 Animal Mechanics.
10 Familiar Account of Lord Bacon's Novum Organum—Part 1.
11 Mechanics—Third Treatise. On Friction.
12 Optics—Part 1.
13 Optical Instruments—Part 1.
14 Vegetable Physiology.
15 Electricity—Part 1.
16 Mathematical Geography.
17 Arithmetic and Algebra—Part 1.
18 Novum Organum Scientiarum—Part 2.
19 Optics—Part 2.
20 Life of Cardinal Wolsey.
21 Optical Instruments—Part 2.
22 Electricity—Part 2.
23 Physical Geography—Part 1.
24 Life of Sir Christopher Wren.
25 Arithmetic and Algebra—Part 2.
26 Thermometer and Pyrometer—Part 1.
27 Outline of General History—Part 1.
28 History of Greece—Part 1.
29 Navigation.
30 History of Greece—Part 2.
31 Life of William Caxton.
32 History of Greece—Part 3.
33 Thermometer and Pyrometer—Part 2.
34 History of Greece—Part 4.
35 Geometry—Part 1.
36 History of Greece—Part 5.
37 Geometry—Part 2.
38 History of Greece—Part 6.
39 Sir Edward Coke.
40 History of Greece—Part 7.
41 Galvanism.
42 Geometry—Part 3.
43 History of Greece—Part 8.
44 Animal Mechanics—Part 2.
45 Life of Mahomet.
46 Polarisation of Light—Part 1.

N.B. A Subscription of £1. constitutes a Member of the Society, and entitles the Subscriber to the Numbers of the Library of Useful Knowledge, published twice a month.

The Office of the Society is at No. 4, Holborn Court, Grey's Inn.

WILLIAM CLOWES, Printer, Stamford Street.

We thus perceive that within the limits of from 28 to 30 degrees on each side of the equator, the movements of the atmosphere are carried on with great regularity; but beyond these limits, the winds are extremely variable and uncertain, and the observations made have not yet led to any satisfactory theory by which to explain them. It appears, however, that beyond the region of the trade-winds, the most frequent movements of the atmosphere are from the *south-west*, in the north temperate zone, and from the *north-west*, in the south temperate zone. This remark must be limited to winds blowing over the ocean and in maritime countries; because those in the interior of continents are influenced by a variety of circumstances, among which, the height and position of chains of mountains are not the least important. These south-west and north-west winds of the temperate zones are most likely occasioned in the following manner:—In the torrid zone there is a continual ascent of air, which, after rising, must spread itself to the north and south in an opposite direction to the trade-winds below: these upper currents, becoming cooled above, at last descend and mix themselves with the lower air; part of them may perhaps fall again into the trade-winds, and the remainder, pursuing its course towards the poles, occasion the north-west and south-west winds of which we have been speaking. It has also been conjectured that these winds may frequently be caused by a decomposition of the atmosphere towards the poles, from part of the air being at times converted into water.

Hurricanes have been supposed to be of electric origin. A large vacuum is suddenly created in the atmosphere, into which vacuum the surrounding air rushes with immense rapidity, sometimes from opposite points of the compass, spreading the most frightful devastation along its track, rooting up trees, and levelling houses with the ground. They are seldom experienced beyond the tropics, or nearer the equator than the 9th or 10th parallels of latitude; and they rage with the greatest fury, near the tropics, in the vicinity of land or islands, while far out in the open ocean they rarely occur. They are most common among the West India islands, near the east coast of Madagascar, the islands of Mauritius and Bourbon, in the Bay of Bengal at the changing of the monsoons, and on the coasts of China.

Whirlwinds sometimes arise from winds blowing among lofty and precipitous mountains, the form of which influences their direction, and occasions gusts to descend with a spiral or whirling motion. They are frequently, however, caused by two winds meeting each other at an angle, and then turning upon a centre. When two winds thus encounter one another, any cloud which happens to be between them is of course condensed and turned rapidly round; and all substances sufficiently light are carried up into the air by the whirling motion which ensues. The action of a whirlwind at sea occasions the curious phenomenon called a *water-spout*, which is thus described by those who have witnessed it. From a dense cloud a cone descends in the form of a trumpet with the small end downwards; at the same time, the surface of the sea under it is agitated and whirled round, the waters are separated into vapour, and ascend with a spiral motion till they unite with the cone proceeding from the cloud; frequently, however, they disperse before the junction is effected. Both columns diminish towards their point of contact, where they are not above three or four feet in diameter. In the middle of the cone forming the water-spout, there is a white transparent tube, which becomes less distinct on approaching it, and it is then discovered to be a vacant space in which none of the small particles of water ascend; and in this, as well as around the outer edges of the water-spout, large drops of rain precipitate themselves. In calm weather, water-spouts generally preserve the perpendicular in their motion; but when acted on by winds they move on obliquely—sometimes they disperse suddenly, at others they pass rapidly along the surface of the sea, and continue a quarter of an hour or more before they disappear. A notion has been entertained that they are very dangerous to shipping, owing to the descent, at the instant of their breaking, of a large body of water sufficient to sink a ship; but this does not appear to be the case, for the water descends only in the form of heavy rain. It is true, that small vessels incur a risk of being overset if they carry much sail; because sudden gusts of wind, from all points of the compass, are very common in the vicinity of water-spouts.

GIFT
JAN 10 '36

On Physical Climate.

Circumstances which determine its character—Mean annual Temperature—Extremes of Heat and Cold—Isothermal Lines—Temperatures of the Southern and Northern Hemispheres compared—Quantity of Evaporation and of Rain in various Latitudes—Character of the Seasons in the different Zones.

The term *climate* is applied to the state of the air, in order to express that particular combination of temperature and moisture which exists in the atmosphere of any greater or less extent of country. The climates of different regions of the globe, and the causes which occasion their great diversity, are interesting matters of inquiry. If an uniform climate had been communicated to the whole globe, we should not have seen such wonderful variety among the animal and vegetable tribes; and many things that now raise the delight, or administer to the necessities of the human race, would have been entirely unknown. It might at first be imagined that the climate of any particular place depended solely upon the action of the sun; but, upon further consideration, we shall find that there are other circumstances to be taken into account: were it not so, any two places having the same latitude, and consequently receiving the sun's rays at the same angle, would enjoy similar climates, which is by no means the case. It is a wise ordination of Providence that the sun's action is modified in such various ways, as to produce a more equal distribution of heat over the surface of the globe than would otherwise have existed; by means of which, large regions are adapted to the residence and support of man, that would else, from extreme heat or cold, have been quite uninhabitable.

There are eight circumstances which determine physical climate:—1. The power of the sun's immediate action, which increases in proportion as we approach the equator; 2. elevation of the ground above the level of the ocean; 3. position with respect to the great seas; 4. quarter towards which the surface of the country slopes; 5. position and direction of chains of mountains; 6. nature of the soil; 7. degree of cultivation and improvement to which the country has arrived; 8. prevalent winds.

1. The amount of the immediate solar heat depends upon the position of the sun in the ecliptic, because to all places (whatever their distance from the Equator,) this position determines the length of the day, and the direction in which the sun's rays strike the earth. When the sun remains a long time above the horizon, his continued action causes a powerful accumulation of heat; the nights also being short, but little of this heat escapes during his absence. On this account it is, that even within the arctic circle the summer temperature is sometimes quite oppressive*. The direction in which the rays fall upon the earth is another important consideration; their greatest force being experienced when they are perpendicular to the surface. On the contrary, when the sun is near the horizon, his rays merely glance along the ground, and many of them, before they reach it, are absorbed and dispersed, owing to the density of the lowest stratum of the atmosphere along which they have to pass. Bouguer calculated that, out of 10,000 rays falling upon the earth's atmosphere, 8123 arrive at a given point if they come perpendicularly; 7024, if the angle of direction is 50 degrees; 2831, if it is 7 degrees, and only 5, if the direction is horizontal.

2. It is well known how the temperature of a place is influenced by the elevation of the land. In proceeding from the equator towards either of the poles, without altering our height above the level of the sea, we must travel a great distance before we find the mean annual temperature reduced even a few degrees; but, by increasing our elevation, a rapid change of temperature will be experienced, till we arrive at the point where constant frost prevails. The extreme cold which exists in the upper region of the atmosphere seems to be owing to the expansion of the air (see chap. vii. of the *Treatise on Heat*); partly, also, to the circumstance of that region being beyond the reach of the heat reflected from the surface of the earth. The decreases of heat, at equal ascents, are not altogether uniform, as they take place more rapidly in the higher parts of the atmosphere. The annexed table, abridged from one drawn up by Professor Leslie, shows that even under the equator, where the sun's direct influence is most powerful, an ascent of rather more than 15,000 feet (about 2⅞ miles) above the level of the sea, will bring us within the region of perpetual frost. This provision of nature of course increases considerably the number of habitable countries within the torrid zone.

---

* In Norway, as high as latitude 70 degrees, the thermometer has been seen to rise above 90 degrees.

Latitude.	Mean Temperature at the level of the sea.	Height of Curve of Congelation.
0	84.2 Fahr.	15,207 feet.
10	82.6	14,764
20	78.1	13;478
30	71.1	11,484
40	62.6	9001
50	53.6	6334
60	45	3818
70	38.1	1778
80	33.6	457
90	32	0

3. The effect of the sea is to *equalise* temperature, so that a maritime country is not liable to such extremes, either of heat or cold, as an inland one. The sea itself being of a very equable temperature, the winds which pass over an extent of it partake somewhat of the same character. When a *cold* wind passes over sea it receives part of the warmth of the water, the upper particles of which being thus rendered cooler, and consequently heavier than those below, descend and are succeeded by warmer particles; so that there is a *continual* tendency in the sea to temper a cold wind passing over its surface. A cold wind, blowing overland, is at first rendered warmer by the earth's surface; but this surface quickly becoming cooled, ceases to have any effect upon the wind, which, therefore, travels on with undiminished rigour. Again, a *warm* wind, in passing over sea, is cooled by the agitation which it produces bringing up cooler water from below, as well as by the constant evaporation which it occasions; the surface of the water also cannot, as that of land, be powerfully heated by the sun's rays, because it affords them a free passage, and therefore it cannot communicate heat to the atmosphere in the degree which the land does. From these circumstances it results, that, though a place situated inland, and another upon a coast may have the same mean annual temperature, the range of the thermometer at each will be very different, the summers of the latter will be cooler, and the winters milder than those of the former. It is from this cause that islands are so much more temperate than continents. It follows, too, that countries in our hemisphere will be rendered warmer by having large tracts of land to the south and sea to the north, and cooler when the relative position of these two is reversed. This fact is exemplified by a comparison of the climate of India with that of Africa north of the equator, the heats of the former country being much more supportable than those of the latter. Not only the temperature of a wind, but also its degree of moisture, depends upon the nature of the surface over which it passes. A wind coming up from the ocean is loaded with vapours, but one sweeping over an extent of land is rendered dry and parching. This explains to us why, in our own island, a south-west and an easterly wind are so opposite in character.

4. The aspect of a country has an influence upon its climate, for this reason, that the angle at which the sun's rays strike the ground, and consequently the power of those rays in heating it, varies with the exposure of the soil relatively to that luminary. When the sun is elevated on the meridian 45 degrees above the horizon, his rays fall *perpendicularly* on the side of a hill facing the south at an equal angle, while the plain below receives them at an *angle of 45 degrees*. Supposing the north side of the hill to have a similar slope, the rays would run *parallel* to its surface; and their effect be very trifling, but if the declivity were still greater, the whole surface would be in the shade. This, though an extreme case, serves to show why temperature varies with the inclination of the earth's surface. Since the warmest part of the day is not when the sun is on the meridian, but, owing to the accumulation of the heat, two or three hours afterwards, it follows that, in our hemisphere, a south-south-west or south-western aspect is the warmest, and a north-north-east, or north-eastern, the coldest, if no local circumstances exist to make it otherwise. The effect of aspect is, of course, most strikingly seen in regions covered with high mountains. In the Vallais in Switzerland, the Alps are on one side covered with ice, while vineyards and orchards flourish on the other.

5. Mountains affect a climate in more ways than one. They attract the vapours in the atmosphere, and causing them to condense, give rise to those violent rains which are often experienced in the neighbourhood of lofty ranges. They also afford shelter from winds. In narrow valleys, the sides of which in summer strongly reflect the sun's rays, this shelter sometimes renders the heat very injurious. One reason why the central and southern parts of European Russia are exposed to greater cold than their latitude and inclination southward would lead us to expect, is the absence of any chain of mountains to protect them from the full influence of the winds blowing from the White Sea and the Ural Mountains. The inhospitable climate of Siberia arises from its descent towards the north exposing it to the winds of the

Frozen Ocean, while at the same time the vast mountainous chains that cross central Asia, intercept the southern winds, whose access, would tend to mitigate the rigour of the atmosphere.

6. It is evident that the nature of the soil must very materially operate upon climate. One soil acquires heat, keeps its acquired heat much longer, or reflects it more readily, than another. One, which from its porous character allows the rain descending upon it to pass freely into the earth, will emit much fewer exhalations than one which retains the waters near the surface. Thus clayey or marshy grounds lower the temperature, and especially in hot and humid climates, affect the atmosphere in a manner pernicious to health; on the other hand, those which are light, stony, or calcareous, tend to make the atmosphere salubrious. The great cold, and the unwholesome air that prevail in the Russian governments of Astracan and Orenburg, lying to the north of the Caspian Sea, are attributed partly to the saline nature of the soil; and it is well known that the arid tracts of sand in Africa and Arabia, conduce not a little to the excess of heat under which those countries labour.

7. Without cultivation, few climates would be healthy or agreeable. In countries to which the labours of civilized man have never been extended, the rivers, spreading themselves over the low grounds, form pestilential marshes, and forests, thickets, and weeds are so numerous and impenetrable, as to prevent the earth from receiving the beneficial influence of the sun's rays. The air, from these causes, is constantly filled with noxious exhalations. But the efforts of the human race, conducted with skill and perseverance, produce a surprising change: marshes are drained; rivers embanked; the soil broken up by the plough is exposed to the sun and wind, and the clearing away of the forests raises the temperature, and allows a freer circulation to the atmosphere. There is little doubt that many parts of Europe enjoy a milder climate now than they did in the time of the Romans, or even at periods much more recent. Several districts in North America have experienced, as the country has become more widely settled, a similar improvement of climate. The destruction of forests may, however, be carried to a pernicious extent, either by depriving a country of shelter from particular winds, or (especially in hot climates) by lessening too much the quantity of moisture; it being well known that there is a great evaporation from the leaves of vegetables. The sultry atmosphere and dreadful droughts of the Cape de Verde islands are owing to the destruction of the forests; and Greece, Italy, and other countries are said to have been deteriorated in climate from the same cause. It is attributed to this also that the southern part of Iceland is more accessible than formerly to the cold which proceeds from the Arctic Ocean.

8. The combined influence of the several causes of physical climate which we have been considering will be variously modified by the *prevalent winds* of a country. This is obvious enough, because we know that the character of a wind depends upon the quarter whence it comes, and the surface over which it passes. Great Britain, for example, would in a great measure lose its insular climate, if its prevailing winds came across the continent, instead of from the Atlantic Ocean.

Notwithstanding the several circumstances which we have thus pointed out as influencing climate, and which occasion numerous local irregularities, the temperature, with these exceptions, becomes gradually lower as we pass from the equator towards either of the poles. By this is not to be understood the temperature of any particular day, or even season, but the *mean annual temperature*, which is obtained by adding together the temperatures of all the months*, and dividing the sum by the number of months in the year; so that the mean annual temperature expresses that height at which the thermometer would stand at any place, if we could suppose it perfectly stationary throughout the whole year. It is not sufficient, however, to take one year only, but a series of at least ten or fifteen years, from the *mean* result of which series a conclusion nearly accurate may be drawn. Though the temperature of a place is continually varying, and though the changes occur frequently in the most sudden manner, it never differs more than a certain number of degrees either way from its mean state; and when it has reached either extreme, a reaction may shortly be expected. In the torrid zone any excessive accumulation of heat is prevented by the constant blowing of the trade-winds from cooler regions; and in the frigid zones the tendency to great extremes which arises from the continued presence of the sun in summer, and his long absence in winter, is counteracted by the circulation of the atmosphere, and by the circumstance that the fields of ice, in melting, absorb large quantities of heat, while on the other hand warmth is given out when the surface of the ocean is being frozen over.—(See chap. ix. of the *Treatise on Heat.*)

---

* The temperature of each month is the average of all the daily temperatures in the month, and the daily temperature is the average of several observations made at stated periods, every hour or half hour, for instance, each day (24 hours). It is evident that such frequent observations would be very troublesome, and shorter methods of discovering the mean annual temperature of a place have therefore been sought after. Rules have been laid down for calculating what this is under different parallels of latitude, and the results no doubt approach very near to the truth; but it would obviously be incorrect to apply these rules to any particular place, because we should be uncertain how the climate of that place was affected by local circumstances. The best method is to ascertain at what period in each day (taking one day with another) the thermometer stands at its mean height for the day; and when this has been ascertained, one observation each day, at that period, will be sufficient. In this country it would appear that the time at which the thermometer shows the mean heat for the day, is about a quarter or half past eight in the morning. Another method of discovering the mean annual temperature at any place, is to observe the height of the thermometer in cavities at some depth below the earth's surface, it being found that this height nearly corresponds with the mean annual height in the air above. M. Lacroix, in his work on Physical Geography, states that in the caves below the Observatory at Paris, (lat. 49°) about 85 feet below the surface, Fahrenheit's thermometer constantly stands between 52° and 54°, scarcely ever varying two degrees, while above, the difference of temperature between summer and winter sometimes exceeds 90°. In the salt mines at

The extremes of temperature which have been witnessed in different parts of the globe are, nevertheless, very considerable. In New South Wales, Fahrenheit's thermometer sometimes rises to 100 degrees and upwards; at Pekin, in China, it has been seen at 110°, and at different places in India at 110°, and even 115°. Major Denham, in his late travels in Africa, observed it more than once at 113°; and at Belbeis, in Egypt, it is said to have risen, under the influence of the hot wind from the desert, to 125°.* These heights are intended to express the degree of heat in the *shade*. The accuracy of the observations depends upon the circumstances under which they were made, since it is requisite that the thermometer should be in a situation freely exposed to the outer air, and also where there are no surfaces immediately near to reflect the sun's rays. The most extreme cold experienced is in the northern parts of Asia and America. In Siberia, as far south as the 58th degree of latitude, M. Pallas observed the freezing of mercury*. The same phenomenon is by no means unusual at Quebec. At Hudson's Bay the spirit thermometer has sunk to — 50°, and at Melville island, (N. lat. 74¾°,) where Captain Parry wintered in his first north-western expedition, it fell, on the 15th February, 1820, to 55 degrees below *zero*.

A treatise upon *isothermal*† *lines*, published some years ago by M. Humboldt, gives several curious results drawn from various observations upon temperature made by himself and others. A few of these it will be proper to notice here, because they illustrate, in a striking manner, the fact upon which we have already remarked, that the climates of places do not depend solely upon the direct action of the sun. If it were so, all places having the same latitude would experience the same mean annual temperature. It had long been known that this was not the case, especially on comparing Europe with America; but M. Humboldt's statements will enable us to form some idea of the amount of the difference. According to that philosopher, the isothermal line which indicates the temperature of 32 degrees (the freezing point of water) passes between Ulea, in Lapland (lat. 66°) and Table Bay, on the coast of Labrador, in North America, lat. 54°. The isothermal line of 41 degrees passes near Stockholm, lat. 59½°, and St. George's Bay, Newfoundland, lat. 48°. The line of 50 degrees runs through the Netherlands, lat. 51°, and near Boston, in the United States, lat. 42½°; that of 59 between Rome and Florence, lat. 43°, and near Raleigh, in North Carolina, lat. 36°. Taking similar latitudes, the following are the differences of temperature between the west of Europe and the east of North America:—

Latitude.	Mean temperature in the West of Europe.	Mean temperature in the East of America.	Difference.
°	°	°	°
30	70.1	66.8	3.3
40	63.1	54.5	8.6
50	50.8	37.9	12.9
60	40	24	16

Wielickza, in Poland (lat. 50°), from the depth of 320 to that of 745 feet, the thermometer stands at about 50°. At Cairo, in Egypt, (lat. 30°), at the bottom of Joseph's well (210 feet deep), it stands at 70°; in the mines of Mexico (lat. 20°), 1650 feet below the surface, it stands at 74¾°. In these heights we discern how the temperature increases on approaching the equator.

* When the thermometer is raised to such an extraordinary height as this, it is probably the effect produced by very fine particles of sand which are carried along by the atmosphere. Humboldt, in the arid plains of South America, has, during a *wind of sand*, seen it at 114½ degrees nearly; while in Fezzan, in the North of Africa. it has risen, doubtless from the cause just noticed, to 125.6 degrees.

* This takes place when the mercury has sunk to 39 or 40 degrees below *zero*.

† This is derived from two Greek words, and signifies *equal heat* or *temperature*. An isothermal line, therefore, is a line drawn over places which have the *same temperature* (*annual*, unless otherwise expressed.)

From the annexed table, there appears to be nearly as much difference between the mean temperatures of the eastern and western parts of the old continent as between those of the opposite shores of Europe and America :—

Places.	Latitude.	Longitude.	Mean temperature.
St. Maloes .	48° 39′ N.	1° 57′ W.	54.5°
Amsterdam .	52 22	4 40 E.	53.4
Copenhagen .	55 41	12 30	45.7
Upsala . . .	59 51	17 48	41.9
Naples . . .	40 50	14 10	63.5
Vienna . .	48 11	16 22	50.5
Warsaw . .	52 14	21 10	48.6
Moscow . .	55 45	37 31	40.1
St.Petersburgh	59 56	30 25	38.8
Pekin (China)	39 54	116 28	54.9

M. Humboldt, after tracing the isothermal lines across America, concludes that, in California and thence northward along the western side of that continent, the temperature is nearly the same as in similar latitudes on the western side of Europe. "Europe," he then observes, "may be considered altogether as the western part of a great continent, and, therefore, as being subject to all the influence which causes the western sides of all continents to be warmer than the eastern. The same difference which has been observed between the two shores of the Atlantic, exists between the two opposite coasts of the Pacific. In the north of China, the extremes of the seasons are much more felt than in the same latitudes in New California, and at the mouth of the Columba. On the eastern side of North America, the same extremes occur as in China. New York has the summer of Rome and the winter of Copenhagen. Quebec has the summer of Paris and the winter of Petersburgh. In the same manner, at Pekin, which has the mean temperature of Britain, the heat of summer is greater than at Cairo, and the cold of winter as severe as at Upsal. This analogy between the eastern coasts of Asia and America sufficiently proves that the inequality of the seasons depends upon the prolongation and enlargement of the continents towards the pole, and upon the frequency of the north-west winds, and not upon the proximity of any elevated tracts of country." The following table illustrates the preceding remarks :—

Places.	Latitude, North.	Mean annual temperature.	Mean temperature.						Difference in the heat of these months.
			Winter.	Spring.	Summer.	Autumn.	Coldest M.	Hottest M.	
	° ′	°	°	°	°	°	°	°	°
Philadelphia	39.56	54.86	33.98	53.06	75.20	56.32	32.70	77.00	44.30
Pekin .	39.54	54.86	26.42	56.30	82.58	54.32	24.62	84.38	59.76
Nantes . .	47.13	54.68	40.28	54.50	68.72	55.58	39.02	70.52	31.50
Rome .	41.53	60.44	45.86	57.74	75.20	62.78	42.08	77.00	34.92
Paris . .	48.50	51.44	37.92	49.64	64.40	51.26	35.96	67.46	31.50
Quebec .	46.47	41.72	14.18	38.84	68.00	46.04	12.74	73.40	60.66
Upsala . .	59.51	41.9	24.98	39.38	60.20	42.80	24.26	61.88	37.62

The fact that places which have the same annual temperature experience very different seasons, is clearly exhibited in this comparison. From Humboldt's inquiries, it appears that the lines which mark the winter temperature deviate much more from the parallels of latitude than those which express the mean annual temperature. In Europe the latitudes of two places which have the same annual heat, never differ more than 8° or 9° : but the difference of latitude in those having the same winter temperature is sometimes no less than 18° or 19°. The winter of Scotland is as mild as that of Milan. With respect to summer, the same heat takes place at Moscow and at the mouth of the Loire, though the former is nearly 9 degrees north of the latter. Ireland is remarkable for mild winters and cold summers; the mean temperature in Hungary for the month of August is 71°.6, while in Dublin it is no more than 60°.8.

It is generally believed that, beyond a certain distance from the equator, the temperature of the southern is lower than that of the northern hemisphere. In speaking of the temperature of the ocean, we have already observed that ice is fallen in with much sooner in sailing towards the south, than it is in approaching the north pole. Humboldt says, that near the equator, and indeed through the whole of the torrid zone, the temperature of the two hemispheres appears to be the same; but that the difference begins to be felt in the Atlantic about 22° of latitude; the mean temperatures of Rio Janeiro and Havannah, places at about an equal distance from the equator (23 degrees) being in the latter instance 76°.4, and in the former only 74°.5.—The southern climates generally differ from the northern with respect to the distribution of temperature through the different parts of the year. In the southern hemisphere, under the isothermal lines of 45° and 50°, there are summers which, in our hemisphere, belong to the lines 35½° and 41°. There is no accurate information as to the mean temperature of any place beyond 50° of south latitude; but there is every reason to suppose that it differs considerably from that of places in the same degree of north latitude.

The same writer, in the second volume of his Personal Narrative, presents the following comparison of the temperature of the air in both hemispheres. The observations employed in drawing it up were all made at sea, except those from which the mean temperature for S. lat. 34° was deduced, which were made at the Cape of Good Hope.

Latitude.	Corresponding Months.		Mean Temperature of the Months. Southern Hemisphere.	Mean Temperature of the Months. Northern Do.
0°—15°	December	Summer	82.4°	
	June		. .	83.3
18	October	Autumn		79.7
	April		81.5	
2—26	January	Winter	. .	66.74
	July		72.5	
”	September	Autumn	. .	68.9
	March		69.44	
34	December	Winter	. .	59.72
	June		56.84	
”	February	Winter	. .	62.6
	August		62.24	
43	July	Summer	. .	64.76
	January		59.36	
48	June	Summer	. .	63.86
	December		44.6	
58	July	Summer	. .	56.3
	January		43.16	

The coldness of the southern hemisphere has frequently been attributed to a circumstance quite inadequate to explain it, namely, that of the sun being a shorter time (by 7¾ days), on the south, than on the north side of the equator. A much greater influence than we can assign to this cause, must be ascribed to the very large proportion which the ocean bears to the land of the southern hemisphere, in consequence of which its climate differs from that of the northern, in the same way as an insular climate differs from a continental one. But even this is not altogether a sufficient explanation, and there still remains a circumstance that deserves attention. The absence from the south polar regions of any great extent of land, and the manner in which the South American continent terminates, permit the grand current of the antarctic ocean to flow freely all round that part of the globe, towards the equator. This current, being unchecked till it is lost in the westerly movement of the ocean, carries along with it the circumpolar ice into very low latitudes; and the continual absorption of heat by the melting of the ice, as it gradually advances into warmer parts, keeps the air at a lower temperature than in the northern hemisphere, where circumstances are not favourable to the passage of the polar ice out of the regions in which it is formed. Beyond the limit, however, at which the ice disappears, but little effect will be produced on the temperature by its melting, and we accordingly find that within the torrid zone, the warmth of one hemisphere is the same as that of the other, and that as far as the 35th, or even 40th degrees of latitude, there is no important difference.

The question has sometimes been agitated, whether the general temperature of the globe suffers any change. Some have gone so far as to imagine that it gradually diminishes, others have been of opinion that it receives an augmentation. Neither of these theories has very solid foundation; it is scarcely more than a century since the thermometer was rendered a correct measure of heat, and the number of observations made with it in different parts of the world is by no means sufficient to form a basis for such sweeping conclusions. If we possessed a regular series of observations taken in various countries, and extending through three or four centuries, we should most likely be enabled to discover a mean state both of temperature and moisture to which the atmosphere continually returns; and there is no doubt that if we could obtain a clear insight into the complex machinery which regulates the seasons, we should behold the same beautiful harmony, and the same system of compensation for temporary and apparent irregularities, which we are able to discern in the movements of the heavenly bodies. Independent, however, of any question as to the general temperature of the globe, a notion has been entertained that throughout Europe, a more mild and genial climate formerly prevailed: but such historical evidence as can be collected tends to prove exactly the reverse; and that the climate, as might be supposed, has, generally speaking, improved with the advance of cultivation. A discussion of this subject will be found in the first article of the Edinburgh Review, No. LIX., published in June, 1818. That article contains a list of the remarkable seasons which have taken place in Europe for several centuries past, and from the view there given we may venture to conclude, that severe cold is of much rarer occurrence than it was in former ages.

Having thus noticed the subject of temperature, it will be proper to advert to the amount of moisture which the atmosphere contains in different parts of the globe. In the course of this inquiry we shall not make use of the results given by the hygrometer*, because that instrument is neither so well known, nor brought to such a correct standard as the thermometer, but merely give the quantity of evaporation, and the depth of rain that has been observed to fall at several places upon the earth's surface.

Other things being equal, evaporation is the more abundant, the greater the warmth of the air *above* that of the evaporating body, and least of all when their temperature is the same. Neither does much take place whenever the atmosphere is more than fifteen degrees colder than the surface upon which it acts. Winds powerfully promote evaporation, because they bring the air into continual, as well as into closer and more violent contact with the surface acted upon, and also, in the case of liquids, increase, by the agitation which they occasion, the number of points of contact between the atmosphere and the liquid. It must be familiar to every person that the same quantity of water spread over a larger space, is dried up in a less period.

In the temperate zone, with a mean temperature of 52¼ degrees, the annual evaporation has been found to be between 36 and 37 inches. At Cumana, on the coast of South America (N. lat. 10½), with a mean temperature of 81.86 degrees, it was ascertained to be more than 100 inches in the course of the year; at Guadaloupe, in the West Indies, it has been observed to amount to 97 inches. The degree of evaporation very much depends upon the difference (greater or less) between the quantity of vapour which the surrounding air is able to contain *when saturated*, and the quantity which it actually contains. M. Humboldt, from observations made in the passage across the Atlantic, found that in the torrid zone the quantity of vapour contained in the air, is much nearer to the point of saturation than in the temperate zone. The evaporation within the tropics is, on this account, less than might have been supposed from the increase of the temperature.

The quantity of rain falling upon the earth at any place is determined by observing the height of the water collected in a pluviometer or rain-gauge. When an inch is said to have fallen, it implies that the rain which has descended on any given surface would have acquired that depth, supposing none of it to have been absorbed by the ground, and that it received no addition by means of water flowing from the parts adjacent to that surface. The average yearly quantity of rain is greatest within the tropics; and it seems, in general, to diminish, the farther we recede from the equator. In the torrid zone it amounts, at a medium, to 100 or 110 inches, while in the north temperate zone it cannot be stated at more than 30 or 35 inches. These quantities are very differently distributed throughout the year in the two zones: the number of rainy days towards the equator is, in the majority of places, *less* than in the higher latitudes, and the rain consequently descends there in the most violent torrents: at Bombay, 16 inches have been collected in a gauge in the space of twenty-four hours. In general, much more rain falls in mountainous countries than in plains, and in countries covered with extensive forests than in those where wood is less abundant. Annexed, is a table of the annual quantities which have been observed at several places.

Places.	Latitude.	Mean annual quant. of rain.
Island of St. Domingo	19° N.	120 in.
Ditto Grenada . . .	12	112
Calcutta	22½	70 to 75
Rome	42	36
Paris	49	21
London	51½	23 or 24
Liverpool	53½	34
Kendal, Westmoreland	54¼	60
St. Petersburgh . . .	60	16
Upsal	60	16

The average annual fall of rain at Bombay in the ten years 1817 to 1826, was 78.1 inches; of those years the most rainy was in 1822, in the course of which nearly 113 inches fell: whereas in 1824, a season of extreme drought and famine, the supply did not much exceed 34 inches. At Arracan, in 1825, nearly 60 inches were registered in the month of July, and above 43 in August; from which we may conclude, that the whole quantity within the year was at least 150 inches. It would seem, however, that at some places within the tropics the fall is much more copious even than this. Humboldt, on the authority of others, mentions two instances of such excessive rain as almost to induce a suspicion of the correctness of the observations. He informs us that a M. Pereira Lago, by means of a pluviometer, found the quantity of rain, in the year 1821, at San Luis do Maranhao, in Brazil (S. lat. 2½), to be 280¾ inches; and also, that Captain Roussin relates the fact of more than 160 inches having fallen at Cayenne in the single month of February.—(*See vol.* vi. *of the Translation of Humboldt's Personal Narrative, Note to p.* 276.)—At the same time, these accounts appear less surprising when we reflect, that over some of the immense forests of Guyana there is wet weather almost the whole year, and that incessant rains of four or five months are no uncommon occurrence.

---

* Derived from the Greek, and signifies *measure of moisture*.

It must not, however, be imagined that the climate of all hot countries is characterised by such abundant rains; for there are many which, from one year to another, are either almost or entirely destitute of rain. This is the case along an extent of several hundred miles of the coast of Peru, in Egypt and many other parts of Africa, and also in the desert tracts of Arabia. At Cumana, on the North coast of South America, the annual quantity of rain is scarcely 8 inches; and there are other places on the shores of that continent where none falls for several years, but where, nevertheless, vegetation is exceedingly strong, owing to the humidity of the atmosphere.

It is well known that the air becomes drier and less loaded with vapours, the higher we ascend. On looking from the top of the Andes towards the Pacific Ocean, a haziness is often seen, spread uniformly over the surface of the waters to the height of 9500 or 11,500 feet; and this, too, in a season when the atmosphere, beheld from the coast and at sea, *appears* quite pure and transparent. This decrease of vapour in the upper regions of the atmosphere, combined with the rarefaction of the air, is the cause of the beautiful deep tint which the sky assumes when viewed from the summits of lofty mountains. Small white fleecy clouds are sometimes, however, seen floating above the Andes at the height of 25,000 feet; from which we may judge, that even on the tops of that range the colour of the sky is not so pure as it would appear, if it were possible for an observer to attain a further elevation. In passing also from the temperate to the torrid zone, the azure hue of the sky is found to augment progressively: the transparency of climate which is so much admired in Italy and Greece is far surpassed by that which invests the plains of Quito and Peru, or the fertile islands of the Pacific Ocean.

In the torrid zone, the temperature ranges within comparatively small limits; and the various phenomena of the atmosphere occur, from one year to another, with a regular and uniform succession unknown in this part of the world. Two seasons, the *dry* and the *rainy*, divide the year. The latter depends upon the presence of the sun; countries north of the line have their wet season when that luminary is in the northern half of the ecliptic, that is, from April to October; while with southern countries it is exactly the reverse. We cannot fail to be struck with this admirable arrangement for affording shelter from the perpendicular rays of the sun, the unrestrained influence of which would be quite insupportable. Humboldt has given us an account of the atmospheric appearances which succeed each other in that part of South America lying between 4° and 10° of north latitude, and to the east of that branch of the Andes which terminates on the Atlantic side of the lake of Maracaybo. Nothing can surpass the clearness of the atmosphere from the month of December to that of January. The sky is then constantly without clouds; and if one should appear, it is sufficient to excite the whole attention of the inhabitants. The breeze from the east and the east-north-east blows with violence. The immense plains (called *Llanos*), which in the rainy season display a beautiful verdure, gradually assume the aspect of a desert; the grass is reduced to powder, the earth cracks; and the alligator and the large serpents remain buried in the dried mud till the first showers of the year awaken them from their lethargy. About the end of February, and the beginning of March, the blue of the sky becomes less intense, the hygrometer indicates greater humidity, and the stars, veiled at times by a slight vapour, lose the steady and planetary light which before distinguished them. The breeze at this period becomes less strong and regular, and is often interrupted by dead calms. The clouds accumulate toward the south-south-east, appearing like distant mountains, with strongly-marked outlines; and from time to time they detach themselves from the horizon, and traverse the vault of the sky with a rapidity that little corresponds with the feebleness of the wind below. At the end of March, the southern region of the atmosphere is illuminated by gleams of lightning; and the breeze then passes frequently, and for several hours together, to the west and south-west. This is a certain sign of the approach of the rainy season, which begins at the Oroonoko about the end of April. The sky becomes obscured, the azure disappears, and a grey tint is spread uniformly over it;—at the same time the heat progressively increases; and soon, dense vapours cover the heavens from one end to the other. The plaintive cry of the howling monkies begins to be heard before the rising of the sun. The atmosphere is at length convulsed by frequent thunder-storms, the rains descend in torrents, and the rivers, rising rapidly above their banks, overspread the plains with extensive inundations.

The occurrence of these periodical rains is capable of being explained in a very simple manner. We have remarked that they always take place in that half of the torrid zone to which the sun is vertical at the time; and that in the northern half they are preceded by the gradual subsidence of the north-easterly breezes, which are followed by calms, interrupted frequently by stormy winds from the south-east and south-west. While the north-east breeze blows with all its strength, it prevents the atmosphere over the equinoctial lands and seas north of the equator from being saturated with moisture. The hot and moist air rises above, and the north-east current continually supplies its place with colder and drier strata. In this way, the humidity of the northern torrid zone, instead of being accumulated and forming condensed vapours, ascends, and flows towards the temperate regions; and, accordingly, while the north-east breeze retains its force, which is when the sun is present in the southern signs, the sky is constantly serene. In proportion, however, as the sun passes over the equator towards the tropic of Cancer, the north-east breeze softens, and by degrees entirely ceases, because the difference in temperature between the northern temperate and the torrid zone is then at its least. The breeze having ceased, the humid air is no longer replaced by drier air from the north; and, under the powerful action of a vertical sun, the vapours rapidly accumulate, till they at length descend in violent rains. This state of things continues till the sun re-enters the southern signs; then is the commencement of cold in the temperate zone, and the current from the north sets in again, —because the difference between the warmth of the equinoctial and that of the temperate regions daily increases. By this current the air of the northern torrid zone is renewed; the rains cease, the vapours disappear, and the sky resumes its clearness and serenity of aspect.

These remarks are principally intended to refer to the seasons in the northern part of South America; but, with certain exceptions, they may very nearly be applied to those of the whole torrid zone —of course bearing in mind that, south of the equator, the rainy season is from October to April, and that the *south-east* corresponds to the *north-east* breeze of northern countries. The period of commencement of the rains is not exactly the same everywhere; and there are places where great anomalies are occasioned by the existence of chains of mountains which attract the vapours and alter the direction of the winds. In the West Indies, and also on some parts of the American continent, *two* wet seasons are distinguished; one of these, however, is of much shorter duration, and has much lighter rains than the other. In India, the rains are brought on by the south-west monsoon.

The four seasons which we distinguish in this country are known only in the temperate zones. Their succession is the most regular and perceptible from the 40th to the 60th degree of latitude; but, in this we speak of Europe only, for both in America and Asia a much shorter interval separates the heat of summer from the cold of winter. That part of the northern temperate zone, which lies between the tropic of Cancer, and latitude 35°, has, in many places, a climate resembling that of regions within the tropics. In Europe, even as high as the 40th degree, the frost in the plains is neither intense nor long-continued; the trees are not stripped of their foliage above two months in the year, and although snow sometimes falls at the level of the sea, even in the 37th degree (at Malaga, for example), it is an occurrence very unusual.

From the 60th degree of latitude to the pole, only two seasons take place. A severe and protracted winter is succeeded immediately by the warmth of summer. The rays of the sun, notwithstanding the obliquity of their direction, produce powerful effects, because the great length of the days is favourable to the accumulation of heat. Even in very high latitudes, the tar on the ship's sides is sometimes melted and made to run down by the sun's action. In the north of Europe the snow is generally dissolved in three or four days, and the flowers almost immediately begin to blow. The breaking up of the thick field of ice which is annually spread over the surface of the arctic ocean, commences in the month of June, and at this season dense fogs are very common, owing to the surface of the water being colder than the air lying over it. These at length disperse, and a short interval of fine weather ensues; but, before the close of August, the approaches of winter are perceived; snow falls; and, as the temperature of the atmosphere declines more rapidly than that of the sea, fogs, called the *frost-smoke*, again arise, which disappear only when the ice has begun to extend itself over the clear spaces of the ocean. It is worthy of remark that, even in the circumpolar regions, the west of Europe still maintains its superiority of temperature over the east of North America; for the sea off North Cape in Norway, though in the 72d degree of latitude, is always open, whereas several degrees further south, off the shores of America, it is annually frozen over.

On the Distribution of Vegetables—Vegetation of the different Zones—Primitive centres of Vegetation.

The subject of physical climate is in itself highly interesting; but it becomes still more so when we extend our view, and consider its effects upon the numerous animal and vegetable tribes which are dispersed over the earth. This dispersion has not been the result of a blind and unmeaning chance; the same wisdom which called them into such beautiful and various existence, has fixed laws for their distribution over the surface of the globe. To these laws (without entering into details which belong to botany and zoology) we shall now direct our attention.

The wide extension of vegetable life furnishes one of the most striking examples of the productive power of nature. Every climate, as we pass from the equator to the pole, or from the plains just raised above the level of the ocean to the summits which are covered with eternal snow, has its peculiar vegetation. Countries, the most inhospitable and locked up in frost nearly all the year, are not entirely destitute of it. On Melville Island (N. lat. 75°), where the duration of winter is nine or ten months, and the mean annual temperature only two degrees above zero, there are places which produce, in abundance, moss, lichen, grass, saxifrage, poppy, the dwarf willow, and the sorrel which is so valuable for its antiscorbutic qualities: the expedition under Captain Parry observed, in a sheltered spot of this island, a ranunculus in full flower in the second week of June. It is thought that even perpetual snow may be the abode of a species of vegetation; for Saussure discovered in it a reddish dust, and a red colouring matter has frequently been observed in snow by navigators in the arctic regions[*].

The absence of light does not altogether prevent vegetable existence; caverns and mines produce certain plants, principally those of the cryptogamous class. In the cave of Caripe, situated to the south-east of Cumana in South America, the seeds, which are carried in by the nocturnal birds called Guacharoes, spring up at the distance of several hundred yards from the mouth of the grotto, wherever they can find mould to fix in. Blanched stalks, with some half-formed leaves, rise to the height of more than two feet; but M. Humboldt, who observed them, could not ascertain the species of these plants, their form and colour being so much changed by the absence of light. Vast fields of marine plants spring from the depths of the ocean, especially towards and within the tropics; the vine-leaved fucus vegetates at the depth of 200 feet, and, notwithstanding, has leaves as green as those of grass. In the Atlantic, between the 23d and the 35th degrees of latitude, and in the 29th and 30th of longitude, the fuci float on the surface in such numbers as to give the appearance of an immense inundated meadow. It is supposed, by many botanists, that they grow at the bottom of the sea, and float only in their ripened state, when torn off by the motion of the waves or otherwise.

Extreme heat is not destructive of vegetation, provided that it be accompanied by humidity. Plants grow, not only on the borders of hot springs, but even in the midst of waters which we should have supposed to be quite unsuited to their existence. Examples of this sort occur in Iceland and many other countries. Even sulphureous exhalations are not fatal to vegetation: it is reported that the interior of the crater of Vesuvius, after a long period of repose, was in 1611 covered with shrubs. The greatest obstacle to it is the absence of moisture; those sandy tracts where rain seldom or never falls, and where the soil is constantly being shifted by the winds, exhibit a hopeless sterility. The verdure of the *oases*, or islands of vegetation, scattered over some parts of the African desert, is maintained by springs which rise up to the surface of the ground. The chemical nature of the soil influences the size and vigour of plants rather than sets limits to their cultivation. Common salt, however, dissolved, and scattered over the earth in large quantities, almost entirely prevents their growth. The fusion which lava undergoes is probably the reason why the progress of vegetation on its surface is so long retarded; whereas, from the ashes thrown out by volcanoes, the most abundant crops are raised.

---

[*] Captain Parry, in his Narrative of the attempt made in the year 1827 to reach the North Pole, mentions some striking examples of this appearance.—"In the course of this day's journey, we met with a quantity of snow, tinged, to the depth of several inches, with some red colouring matter. This circumstance recalled to our recollection our having frequently before, in the course of this journey, remarked that the loaded sledges, in passing over hard snow, left upon it a light rose-coloured tint, which, at the time, we attributed to the colouring matter being pressed out of the birch of which they were made. To-day, however, we observed that the runners of the boats, and even our own footsteps, exhibited the same appearance; and on watching it more narrowly afterwards, we found the same effect to be produced, in a greater or less degree, by heavy pressure, on almost all the ice over which we passed, though a magnifying glass could detect nothing to give it this tinge. The colour of the red snow, which occurred only in two or three spots, appeared somewhat different from this, being rather of a salmon than a rose-colour, but both were so striking as to be the subject of constant remark." This colouring substance has generally been thought to belong to the order *Algæ*.

The scale of atmospherical heat is that which ordinarily determines the character and progress of vegetation. Hence, under the fierce climate of the torrid zone, we need only ascend lofty mountains, to a certain height, in order to behold the trees, fruits, and flowers of the temperate zone; while still higher are found those of the frigid zone. The low vallies of the Andes, towards the equator, are adorned with bananas and palm-trees, while the elevated parts of the chain produce oaks, firs, and several other tribes common to the north of Europe. Near the equator, the oak grows at an elevation of 9200 feet above the sea, and never descends lower than one of 5500 feet; but, in the latitude of Mexico, it is seen as low as 2600 feet. From the height of about 15,000 feet, to the boundary of perpetual congelation, lichens are the only plants visible. Similar gradations, on a smaller scale, are observed among the Alps; on ascending which, chesnuts, beeches, oaks, and pines occur in succession, the last gradually becoming stunted till they disappear not far from the border of perpetual snow. The vegetation which covers the sides of mountains may be divided into distinct zones or bands, each zone containing its peculiar tribes. On the volcano of Teneriffe, one of the Canary Islands (N. lat. 28½°), as many as five of these zones are distinguished[*]:—(1) the region of *vines*; (2) of *laurels*; (3) of *pines*; (4) of the *retama* (an alpine broom); and (5) the region of *grasses*. These zones are arranged in stages, one above another, and occupy, on the declivity of the Peak, a perpendicular height of 11,200 feet.

In the equinoctial region where, in respect of warmth, the seasons differ little from each other, the geographical distribution of plants is regulated almost entirely by the mean temperature of the whole year; but in the temperate zone this distribution depends not so much upon the mean temperature of the year as upon that of the summer season. In Lapland, there are fine forests on the continent at Enontekies, where the mean annual temperature is only 27 degrees, while on the island of Mageroe, where it is more than 32 degrees, only a few scanty shrubs are to be seen. The more vigorous vegetation of Enontekies is the effect of a warmer summer; the mean temperature of July being there 59½°; whereas, at the isle of Mageroe, it is only 46¾°. Some plants in summer require a certain degree of warmth only for a short period; for others, a more moderate warmth is sufficient, if it be of longer duration. The birch and the pine afford an example of this difference. The former tree does not put forth its leaves till the temperature has risen to about 53 or 54 degrees; and in all places where the mean summer heat falls short of this, the birch cannot flourish, however great may be the mildness of the winters. Such is the case on the island just mentioned, and in other parts of Lapland. The pine, on the contrary, requires a long rather than a warm summer. In the interior of Lapland, where the summer, though short, is warm, the birch rises much nearer the line of perpetual congelation than the pine; but in the Alps and other high chains in lower latitudes, where the summer is of longer continuance but colder, the pine is seen after the birch has entirely disappeared.

The frigid zone contains but few species of plants, yet of these the vegetation in summer is extremely rapid. The verdure of those countries, which lie within the polar circle, is confined chiefly to the hills having a southern aspect, and the trees are of very diminutive growth. Besides mosses and lichens, there exist ferns, creeping plants, and some shrubs yielding berries of an agreeable flavour. The arctic regions of Europe are peculiarly favoured; for, in certain parts of Lapland, there are fine forests, and even rye and leguminous plants are produced.

---

[*] Humboldt's Personal Narrative, vol. i.

In the high latitudes of the northern temperate zone are the pine and the fir, which show their adaptation to a cold climate by retaining their verdure in the midst of the rigours of winter. To these, on advancing southward, succeed the oak, the elm, the beech, the lime, and other forest trees. Several fruit trees, among which are the apple, the pear, the cherry, and the plum, grow better in the northern half of this zone; while to its most southern part especially belong the more delicate fruits, such as the olive, the lemon, the orange, and the fig; and, amongst trees, the cedar, the cypress, and the cork.

The space, comprised between the 30th and the 50th parallels of latitude, may be considered as the country of the vine and the mulberry. Wheat extends as far north as the 60th degree; oats and barley a few degrees further. In the southern part of this zone, maize and rice are more commonly cultivated.

The vegetation of the torrid zone is characterised by a wealth, a variety, and a magnificence, which are nowhere to be found in the other regions of the globe. Under the beams of a tropical sun, the most juicy fruits and the most powerful aromatics arrive at perfection; and innumerable productions supply the wants and administer to the luxuries of man. There the grounds yield the sugar-cane, the coffee-tree, the palm, the bread-tree, the pisang, the immense baobab, the date, the cocoa, the vanilla, the cinnamon, the nutmeg, the pepper, the camphor tree, &c. &c. In South America, is the remarkable tree called the *cow-tree*, which, when incisions are made in its trunk, yields abundance of a glutinous and nourishing milk[*]. There are also various sorts of dyewood, and several species of corn peculiar to hot climates; while this zone is not destitute (in its elevated tracts) of every kind which grows in the plains of temperate countries.

Under the equator, the climate best suited for the culture of all kinds of European grain lies between the altitudes of 6000 and 9000 feet above the level of the ocean. Wheat will seldom form an ear below the elevation of 4500 feet, or ripen above that of 10,800. With respect, however, to the lowest height at which corn can be raised between the tropics, there are great irregularities, which tend to prove that the augmentation of heat is not prejudicial to its cultivation, unless attended with an excess either of drought or of moisture. In the environs of La Victoria, a town of Venezuela (lat. 10½° N.), fields of corn are seen mingled with plantations of sugar-canes, coffee, and plantains, at the height of not more than from 1700 to 1900 feet above the sea. The district of Quatro Villas, in the interior of the island of Cuba, furnishes a still more remarkable example; there, fine harvests are raised almost at the level of the ocean. In nearly the same latitudes, on the other side of the Mexican Gulf, the fine fields of wheat are generally between 3800 and 7700 feet of elevation; while on the slope of the mountains of Mexico and Xalapa, vegetation, even at the height of 4320 feet, is so luxuriant, that wheat does not form ears. It is erroneous to suppose that grain degenerates in advancing towards the equator, or that the harvests are more abundant in northern climates. On the contrary, it has been found that nowhere to the north of the 45th parallel of latitude is the produce of wheat so considerable, as it is on the northern coasts of Africa, and in America, on the table-lands of New Grenada, Peru, and Mexico[*]. Near the town of La Victoria above-mentioned, the average produce is three or four times as great as that of northern countries. It is equally large at Buenos Ayres in the 35th degree of south latitude.

The vegetable forms near the equator are in general more majestic and imposing, and the varnish of the leaves is more brilliant. The largest trees are adorned with flowers larger, more beautiful, and more odoriferous than those of herbaceous plants in our zone. It is scarcely possible for an inhabitant of temperate regions to picture to himself the beauty and the grandeur of the vast forests of equinoctial America. Trees which attain a stupendous height and size are covered with profusion of climbing plants, and the same lianas as creep on the surface of the earth reach the tops of the trees, and pass from one to another at the height of more than a hundred feet. By this continual interlacing of parasite plants, the botanist is often led to confound the flowers, the fruits, and leaves which belong to different species. M. Humboldt gives the following striking description of the woods on the banks of the Cassiquiare, on approaching the point where that river branches off from the Oroonoko. "The luxuriousness of the vegetation increases in a manner of which it is difficult, even for those who are accustomed to the aspect of the forests between the tropics, to form an idea. There is no longer a beach: a palisade of tufted trees forms the bank of the river. You see a canal 200 toises (426 yards) broad, bordered by two enormous walls, clothed with lianas and foliage. We often tried to land, but without being able to step out of the boat. Toward sunset we sailed along the bank for an hour, to discover, not an opening (since none exists), but a spot less wooded, where our Indians, by means of the hatchet and manual labour, could gain space enough for a resting-place for 12 or 13 persons."

---

[*] Humboldt, in the 4th vol. of his Personal Narrative, has given an account of this tree. The fecundity of nature in the torrid zone strikingly appears, when we consider the circumstances under which this vegetable milk is produced. "On the barren flank of a rock grows a tree with coriaceous and dry leaves. Its large woody roots can scarcely penetrate into the stone. For several months of the year, not a single shower moistens its foliage. Its branches appear dead and dried; but when the trunk is pierced, there flows from it a sweet and nourishing milk. It is at the rising of the sun that this vegetable fountain is most abundant. The Blacks and natives are then seen hastening from all quarters, furnished with large bowls to receive the milk, which grows yellow, and thickens at its surface."—*Personal Narrative*, vol. iv. pp. 216 and 217.

[*] The mean temperature for three months of summer is, in the north of Europe, from 59° to 66°; in Barbary and in Egypt, from 80½° to 84°; and within the tropics, at between 8950 and 3840 feet of height, from 57° to 78°.

A large proportion of the trees of these majestic forests are more than 100 feet in height; while some, especially of the palms, have an elevation of 150 to 200 feet*. Various instances are recorded of the enormous growth of trees in tropical climates. Humboldt measured on the banks of the Atabapo, a bombax ceiba more than 120 feet high, and 15 feet in diameter. Near the village of Turmero, which lies to the south-west of the city of Caraccas, is the famous *Zamang del Guayre*, a species of mimosa, known throughout the province for the great extent of its branches, which form a hemispherical head more than 600 feet in circumference. The height of its trunk is about 63 feet, and its thickness between nine and ten. The branches extend like an immense umbrella, and bend towards the ground, from which they remain at an uniform distance of 12 or 15 feet. The circumference of this head is so regular, that M. Humboldt traced different diameters, and found them 204 and 198 feet in length. The dragon-tree (*dracæna*) at Oratava, in the island of Teneriffe, is another specimen of enormous growth. Its trunk is about 50 or 60 feet high, and its girth near the roots almost 48 feet. Its average girth is stated by M. de Borda to be 35 feet, 9 or 10 inches. The baobabs are of still greater dimensions than the above. At Senegal, and in the islands of Cape Verd, some were remarked which had a circumference of from 56 to 60 feet, and in another part of Africa one was seen whose diameter was 34 feet (more than 100 in circumference.)

The distribution of plants cannot be explained solely by the influence of climate or by the distribution of temperature; for it frequently happens that similar climates are found in different parts of the globe without identity of productions. The climate of the high mountains of the torrid zone is analogous to that of our temperate zone; yet Humboldt did not discover one indigenous rose-tree in all South America, and it also appears that this shrub is entirely wanting in the southern hemisphere. The genus *erica* (heath) is quite peculiar to the Old World; of the 137 species known, not one is to be met with in the new continent. They seem to be very rare even in Asia. On the other hand, the *cactus* (Indian fig) is confined to the New World. It is true that a similarity exists in respect to their vegetation between very distant countries, where the physical circumstances are alike; but in some instances it is only a general resemblance of the vegetable forms. In many cases the same *genera* recur; but there are comparatively few examples in which identical *species* have been recognized in countries far remote from each other*. Species of pine, beech, elm, &c., are found in America, differing, however, from the Asiatic and European species. "The lofty mountains of equinoctial America (says M. Humboldt) have certainly plantains, valerians, arenarias, ranunculuses, medlars, oaks, and pines, which from their physiognomy we might confound with those of Europe; but they are all *specifically different*." The Antarctic birch (*betula Antarctica*) of Tierra del Fuego corresponds to, but does not exactly resemble the dwarf birch (*betula nana*) of Northern Europe.

According to Humboldt, the species of plants at present known amount to 44,000. Of these, 6000 are *cryptoga-*

---

* Such is the force of vegetation exhibited by American plants in every zone, that in the latitude of 57° N., on the same isothermal line with St. Petersburgh and the Orkney Islands, the Canadian Pine (*Pinus Canadensis*) displays trunks above 150 feet high, and more than six feet in diameter.

* For an explanation of the terms *genus* and *species*, see page 59.

mous[*]. The remaining 38,000 *phanerogamous*[†] plants are thus distributed:—

In Europe	7000
Temperate regions of Asia .	1500
Asia, within the tropics and islands	4500
In Africa	3000
Both the temperate regions of America	4000
In America, between the tropics	13,000
New Holland, and the islands of the Pacific	5000

He also states the proportions of plants which grow in latitudes 0°, 45°, and 68°, to be as the numbers 12, 4, and 1. The mean annual temperatures in these latitudes are respectively 81½°, 55½°, and 32½°, and the mean summer temperatures 82½°, 70°, and 53½°. Within the tropics, the *monocotyledonous*[‡] plants are to the *dicotyledonous*[§], as 1 to 6; between the latitudes 36° and 52°, as 1 to 4; and at the polar circle as 1 to 2. The *annual* monocotyledonous and dicotyledonous plants in the temperate zone amount to one-sixth of the whole phanerogamous class; in the torrid zone they scarcely form one-twentieth, and in Lapland one-thirtieth part. A circumstance worthy of remark is the extreme rarity of the *social* plants between the tropics, that is, of those plants which, like the heath of Europe, live together and cover large tracts of land[||]. In the torrid zone, they are found only on the sea shore and upon elevated plains.

Among the vegetable forms there are some which become more common from the equator towards the poles, as the ferns, the heaths, and the rhododendrons; others, on the contrary, increase from the poles to the equator, among these are the *rubiaceæ*[¶], the *euphorbiæ*, and the leguminous plants; while others, such as the *cruciferæ*[**], the *umbelliferæ*[††], &c., attain their maximum in the temperate zone, and diminish towards the equator and the poles. The vegetable forms present (under the same *isothermal lines*) such constant relations, that when upon any point of the globe we know the number of species belonging to one of the great families, both the whole number of phanerogamous plants, and the number of species composing the other vegetable families, may be estimated with considerable accuracy.

It has been a question discussed among philosophers, in what way the various vegetable tribes were originally diffused over the surface of the earth. *Three* different hypotheses have been maintained upon this subject. The *first* supposes that there was only one primitive centre of vegetation; all species of plants having had their existence originally confined to one tract of the earth, whence they were gradually dispersed over all countries.

This hypothesis was adopted by the celebrated Linnæus. He imagined the habitable world to have been at the commencement limited to one spot, in which were collected the originals of all the species of plants, together with the first parents of all animals and of the human race. As such various natures would require a diversity of climates for their support, he supposed this tract to have been situated in a warm region, and to have contained a lofty mountain range, between the base and the summit of which were to be found all temperatures and climates, from the temperature and climate of the torrid to those of the frigid zone. Linnæus endeavoured to support this hypothesis by referring to the means which are provided for the multiplication and dispersion of plants. Winds, rivers, and marine currents, are all, more or less, instrumental in the conveyance of seeds from one country to another. The former carry the lighter kinds of seeds to immense distances, and the two latter sometimes transport others from the most remote parts. The naturalist just mentioned remarks that the *Erigeron Canadense* was first introduced into the gardens near Paris from Canada; the seeds being scattered by the wind, this plant was, in the course of a century, spread over all France, Italy, Sicily, Belgium, and Germany. The migration of plants by means of currents is also well ascertained, and many instances of it are recorded. On the shores of the Hebrides are collected at times the seeds of the *mimosa scandens*, *dolichos urens*, and several other plants of Jamaica, the isle of Cuba, and the neighbouring continent. These are not the only methods in which the dispersion of species is effected: it is also known that some seeds (as the misseltoe and juniper) are capable of preserving their vitality in the stomachs of birds, and are thus propagated. Lastly, man has introduced various plants into countries where they previously had no existence.

---

[*] Having neither blossoms nor visible fructification.

[†] Having visible organs of fructification.

[‡] Having only one cotyledon or *seed-lobe*.

[§] Having two *seed-lobes*.

[||] Through Jutland, Holstein, Hanover, Westphalia, and Holland, a long chain of hills may be traced, entirely covered with common heath, and the *erica tetralix*. Very little success has attended the efforts made by the farmers to oppose the inroads of these plants.

[¶] One of Jussieu's natural orders of plants, so named from *rubia* (madder).

[**] An order of plants, so named from their petals, four in number, being disposed in the form of a *cross*.

[††] Having an *umbella* or *umbel*. This term is used to designate a particular mode of flowering, which consists of several flower-stalks, or rays, nearly equal in length, spreading from a common point or centre. The flowers of the hemlock and parsley are *umbellate*.

The *second* hypothesis is, that each species of plants originated in and was diffused from a single primitive centre; but that there were several of these centres situated in different parts of the globe, each centre the seat of a particular number of species. The *third* and last hypothesis is, that wherever a suitable soil and climate existed, there the vegetable tribes sprang up; and that plants of the same species were, from the first, spread over different regions.

We proceed to relate some facts which have been observed, and which will enable us to form some opinion as to which of the three preceding hypotheses has the best foundation. The greater number of these facts are taken from the opening part of Dr. James Prichard's work, entitled "Researches into the Physical History of Mankind," where they are brought forward in a similar discussion to the present.

Those plants whose structure is the most simple are found to be very generally diffused. Among the cryptogamous tribes, (such as mosses, lichens, &c.,) which form the lowest order of the vegetable creation, the same species are often met with in the most distant regions[*]. Two-thirds of the lichens observed in Australia, are also natives of Europe; and of the ferns of New Holland, which constitute rather more than 100 species, twenty-eight have been discovered in other countries. Many of the monocotyledonous tribes are also widely spread. Several grasses are common to Europe and Australia. In South America too, not only the mosses, but likewise several grasses, are the same as European species. It is not so, however, when we view the distribution of the more perfect, or of the dicotyledonous plants, there being a very small number of such, which are common to countries distant from each other. With respect to the dicotyledonous tribes, Humboldt has maintained that all the indigenous kinds in those parts of America visited by him are peculiar to that continent, and that the only exceptions to this rule are plants of the sea-coasts, the migration of which is easily to be explained. The observations of Mr. Brown on the botany of Terra Australis (*Southern Land*) tend nearly to the same point. Of the plants already known in that country, 400 species are cryptogamous, 860 monocotyledonous, and 2900 dicotyledonous. Of the 400 cryptogamous, more than 120, that is nearly *one-third* part, are also indigenous in Europe. Of the 860 monocotyledonous, only 30, or about *one twenty-ninth* part, have been found in Europe, and more than half of these are grasses and *cyperoids*. But of the 2900 dicotyledonous species, only 15, or about the *one hundred and ninety-third* part, are the same in Australia as in Europe. Results no less striking have been obtained on comparing the vegetation of other southern countries with that of Europe and the northern regions. Though the proportion of European plants in Australia is so small, it appears to be greater than that which is observed in the south of Africa. The proportion of European species in South America is probably still less than it is in Southern Africa.

From the preceding remarks, it is to be gathered, that the most simply organized tribes of plants are very widely dispersed; that plants of the more perfect or more complex forms are, on the contrary, limited to particular countries; and that the monocotyledonous, which may be considered as tribes of an intermediate class, are neither so extensively spread as the former, nor confined within such narrow limits as the latter.

Some exceptions to this general rule have lately been brought to light by the botanical discoveries made during the expedition to the river Zaire on the west coast of Africa (about 6° S. lat.) From Mr. Brown's observations upon upwards of 600 plants collected in the neighbourhood of that river, it appears that about one-twelfth of the collection consists of species, which are also met with either in India, or on the opposite shores of Guyana and Brazil; and it is a curious fact, that in this number the *more perfect plants are in the greatest proportion.* This apparent anomaly is probably to be explained by the transportation of seeds from one shore to another by means of currents in the inter-tropical seas. Mr. Brown remarked that most of those plants in the African collection which are also natives of other countries, were seen only on the lower parts of the river Zaire, where they bear but a small proportion to the whole vegetation; and that most of the dicotyledonous species are such as produce seeds capable of retaining the germ of life during a long immersion in the waters of the ocean.

---

[*] To explain the extensive diffusion of these species, Linnæus supposed that their seeds, being invisible particles, might be carried to incalculable distances by the winds. It may, however, be remarked, that in the less perfect tribes of plants, the specific distinctions, not being so strongly marked as in the more complex forms, may escape detection; and thus two plants found in distant places may be set down as of the same species, when there is really some minute difference between them.

It will be proper in this place to mention the phenomena belonging to the vegetation of islands. In small islands the most remote from continents the species of plants are very few, and sometimes quite peculiar. Thus in Kerguelen's land, or the island of Desolation, when visited by Captain Cook, the whole flora was found to contain only 16 or 18 plants, all of which were considered to be peculiar to the island. Not a shrub was seen in the whole country. The flora of islands, as far as it is not peculiar to them, generally consists of the same species which grow on the nearest main lands. The different groups seated in the great Southern Ocean which lies between America and Eastern Asia serve as an example; the easternmost islands contain more plants of American families or species, and the western, of those tribes peculiar to India. Islands placed in the neighbourhood of two continents comprise the vegetation of both. Malta and Sicily have plants which belong to Europe, and others of an African stock. The vegetation of the Cape de Verd islands is intermediate between the flora of the Canary isles and that of the African coast.

The facts which have been introduced in the course of this inquiry forbid us to adopt the hypothesis of Linnæus, which considers all plants to have originated from one common centre. The propagation of the several tribes of plants has certainly taken place from a number of different points; since, of various parts of the world, separated by vast distances, each possesses a vegetable kingdom in a great measure peculiar to itself. The third hypothesis to which we alluded is equally untenable; since it is seen that plants are confined to particular tracts, till their seeds are conveyed elsewhere. Numerous instances have occurred in which plants by transportation have acquired a new country, and there become abundant; a striking example of this kind is the dispersion of the *Erigeron Canadense* over Europe, which we have already related. This shows that in the first instance plants of the same species were not produced in all regions possessing a soil and climate suitable for their growth. We have also seen that, when the same species are observed to exist in countries widely separated, the circumstances generally are such as authorise us to infer that they were dispersed from one point. The only hypothesis which remains, and which is reconcileable with all the phenomena observed, is, that the vegetable creation was originally divided into different provinces, and that each country (probably each principal range of mountains) had its peculiar tribes which, at first, existed nowhere else. This conclusion is strengthened by the circumstance of particular plants having an entirely local and insulated existence, growing naturally on some particular mountain, and nowhere else. The cedar of Lebanon is one among several examples of plants of this description. Such instances alone might be deemed conclusive in favour of the hypothesis for which we have been arguing.

On the distribution of Animals—their original dispersion from distinct centres.

In the ascent from the vegetable to the animal world, and from one rank of animal existence to another, the most admirable order is manifest. We are not surprised by sudden steps or encountered by violent contrasts; an evident connection pervades the whole; and though there is a vast diversity when we compare the meanest specimen of organic life with its most perfect and majestic forms, yet between the two an harmonious chain may be traced, and we pass from one extreme to the other by a regular and scarcely perceptible gradation.

The lowest class is that of the *zoophytes* (plant animals), which raise up the coral islands spoken of in a former part of this treatise. They may be regarded as confused masses of beings, none of them endued with a separate life. Nevertheless, there is reason to believe, from the observations of MM. Péron and Lesueur, that each description of zoophyte has its place of residence determined by the temperature requisite for its support. The *molluscæ*, whether naked or covered with shells (*testaceous*)*, possess each an individual existence, and of these it is unquestionable that different species belong to different countries. The pearl oyster arrives at perfection only in the equatorial seas.

---

* The term *testaceous* is in strictness applied only to such fish as have strong, thick, and entire shells; those which have shells, soft, thin, and consisting of several pieces joined together, as the lobster, &c., being called *crustaceous.*

Insects are the next in the scale of animal existence. In the midst of the exuberant vegetation of the torrid zone, the largest and the most splendid of these tribes are to be seen; the butterflies of Africa, of the East Indies, and of America, are adorned with the most brilliant colours; and in the tropical forests, especially those of South America, millions of shining flies present at night almost the appearance of an extensive conflagration. In these countries some races of insects exist in such multitudes, and are armed with such destructive or venomous qualities, as to enable them to lay waste the fruits of the earth through large tracts of country, or to become a source of the most serious personal annoyance and discomfort to man. The white ants (*termites*) raise lofty hillocks; and where they much abound, have been known to excavate the soil to such a degree, as to endanger the safety of houses which happen to stand above the seat of their operations. They devour paper and parchment so rapidly, that whole provinces of Spanish America (Humboldt informs us) do not afford one written document that dates a hundred years back. The *mosquitoes* and other species of the family of *tipulæ* are also formidable enemies to the human race in these climates. Amidst the forests of South America, especially along the banks of particular rivers, there are large tracts which are almost uninhabitable, owing to the thick swarms of these insects and the unceasing torment which they occasion. The lower strata of air to the height of nearly 20 feet from the ground are sometimes so filled with them as to give the appearance of a condensed vapour. During the day, the atmosphere teems with the *mosquitoes*, which are small venomous flies; these are succeeded, at night, by a species of gnats called *zancudoes*. The distribution of these insects is very remarkable, and frequently depends on local circumstances which cannot be explained. They are, in general, found to shun those rivers which have what the Spaniards call black waters (*aguas negras*), and also dry and unwooded spots. They swarm most upon the banks of rivers, and they nearly disappear where the elevation of the ground exceeds two or three thousand feet above the sea*. The annoyance occasioned by insects of this description is not confined to the torrid zone; for even in the Arctic regions of Greenland and Lapland, the short heats of summer give birth to swarms of gnats of another species.

With respect to *fishes*, it is probable that every basin of the ocean has its particular tribes; while, indeed, the regions which some inhabit are well known. Thus the cod, which are distributed over all the northern seas between Europe and America, congregate chiefly upon the great sand-banks to the south-east of Newfoundland. The most remarkable species of fish are met with in the torrid zone and its vicinity. The flying fish hardly extends to any part of the ocean so high as the 40th parallel; but in the voyage to America, hundreds of them are seen by navigators after passing the tropic of Cancer. The largest and most powerful of those fish which possess electrical properties, also live within the torrid zone. The Mediterranean contains four species of electrical torpedoes; but the shocks which they communicate cannot be compared in violence to those of the *gymnoti* (electric eels), which inhabit several of the rivers, and also the stagnant pools, in the llanos of South America. All the inhabitants of the waters dread the society of these animals. It is related that, some years ago, it became necessary to change the direction of a road near Uritucu, in consequence of the number of mules of burden annually lost in fording a river in which the eels were very numerous. The temperature of the waters in which the gymnoti habitually live, is from 78 to 80 degrees: their electric force is said to diminish in colder waters.

The seas of the warm regions contain the shark, which is noted for its extreme ferocity; but the most enormous in size are the whale tribes, which belong more particularly to the high latitudes.

The migration of fishes seems to be occasioned by their seeking for shallow water, in order to deposit their spawn. The herrings, which are supposed to come from the bottom of the Arctic Ocean, proceed every year to the coasts of the British islands, Norway, Sweden, Denmark, Holland, and the United States; and also to those of Kamtchatka and the neighbouring islands. The opinion is, that their innumerable shoals follow the direction of the chains of submarine banks and rocks which they meet with in their progress. Tunnies also migrate regularly every year from the Atlantic Ocean to the Mediterranean.

The hot regions of the globe, and those of America in particular, contain the largest and the most venomous of the order of *reptiles*, including the rattlesnake, and several other kinds armed with deadly poisons; and the boa constrictor, which destroys even the great quadrupeds by the force with which it coils round their bodies. Here, too, the lizard tribe, under the various names of crocodiles, gavials, alligators, and caymans, attain to an immense growth. The largest is the crocodile of the river Nile, which measures, when full grown, even thirty feet in length. It is worthy of remark, that the dry season near the equator has the same effect upon several of the reptile race as the cold of northern countries: in South America, when the swelling of the rivers subsides, and the surface of the llanos becomes parched by the heat, boas and crocodiles bury themselves beneath the mud, and await, in a state of lethargy, the periodical rains. As we proceed into the higher latitudes, reptiles diminish both in number and magnitude, and are, even the worst of them, comparatively harmless.

---

* Humboldt's Personal Narrative, vol. v., p. 86—116.

With respect to *birds*, we might at first be inclined to infer, from the powers of locomotion with which they are gifted, that the existence of each species is not limited to a certain region, and it is true that some of them, including several of the vulture tribe, spread themselves almost over the whole world. But it appears to be generally the case, that particular kinds are confined to a very small range, especially such as have heavy bodies and weak powers of flight. Even the *condor*, which frequently soars at an elevation of four miles, never forsakes the chain of the Cordilleras of Peru and of Mexico; and the great eagle does not quit the ridges of the Alps. The torrid zone possesses a variety of the most beautiful birds, including the humming-bird of America, the cookatoos, the bird of Paradise, the Lories, and several others of the parrot genus. The bird of Paradise is never met with beyond New Guinea and the neighbouring islands. Parrots, in the New World, are seen as high north as the 35th degree; but on the old continent, they do not appear to reach farther than the 28th parallel. Of the birds which cannot fly, each equatorial region insulated by the ocean has its particular kinds. The ostrich of Africa and Arabia, the cassowary of Java and of New Holland, and the Brazilian ostrich, are distinct species, possessing a general similarity of organisation.

The frozen zone has its own kinds of birds, among which are the *strix Lapponicus* (Lapland owl), and the *anas mollissima* (eider duck), which frequents the shores of the Arctic seas, and from whose nests the eider-down is obtained. The several species of *sea-birds* do not wander beyond certain limits assigned to each. The albatross is seen flitting along the surface of the waves, as we approach the 40th parallel of latitude. The sea-swallows and the tropical birds keep within the torrid zone. The penguin of the Northern differs from the manchot of the South Seas.

The migration of birds from one country to another, in consequence of the changes of the seasons, is a remarkable phenomenon. The direction and extent of these migrations are still, in most cases, but imperfectly known. On the approach of winter, swallows, storks, and cranes abandon the northern countries of Europe for the warmer climates of the south. In the equinoctial zone, which is nearly of the same warmth during the whole year, the variations of drought and humidity appear to influence the habits of animals in the same manner as the great changes of temperature in our climates. In South America, when the Oroonoko begins to swell with the rains, an innumerable quantity of ducks remove from eight and three degrees of north, to one and four degrees of south latitude, toward the south-south-east. These birds quit the valley of the Oroonoko at this period, doubtless because the increasing depth of the waters and the inundations of the shores prevent them from catching fish and insects. In the month of September, when the Oroonoko decreases and retreats within its bed, they return from the Amazon and the Rio Branco towards the north. The southern coasts of the West India islands also receive every year, at the season of the inundations of the great rivers of terra firma (the continent), numerous flights of the fishing birds of the Oroonoko, and of its tributary streams. It is in obedience to a similar instinct, that, during the heats of summer, the humming-birds advance in pursuit of insects into the northern parts of the United States, and even into Canada.

Quadrupeds are an order of animals more perfectly organised than any of those which have been under consideration; while, as they are in many instances immediately connected with man, and altogether come more under his observance, their distribution presents a more ample subject for investigation. The hot regions towards the equator furnish this order in the utmost number and variety; and many of its tribes are there distinguished for their size, their amazing strength, or the ferocity of their dispositions. The lion, the tiger, the elephant, the rhinoceros, the hippopotamus, the panther, the leopard, the hyæna, and the camelopard, are all inhabitants of the torrid zone and its vicinity. In the temperate regions, the animals are of much smaller dimensions; and the only beasts of prey are the wolf, the bear, the lynx, and the wild boar; but there the domestic tribes are reared in all their perfection. The white or Polar bear, which is quite different from the common bear and much more formidable, inhabits the coasts of the Arctic Ocean; so that, under both extremes of temperature, the animal creation assumes a character of excessive ferocity.

The *domestic* animals have been conveyed by man to various parts of the world, and are therefore very widely dispersed. Under this title are included the dog, the cow, the sheep, the goat, the horse, the ass, the pig, and the cat. Humboldt states (contrary to what has been supposed by some), that the cows in the equinoctial parts of South America will yield as rich a milk as in temperate countries. The ass is not capable of enduring cold so well as others of the domestic races: when beheld in the northern regions of Europe, he is quite a degenerate animal; south of the 40th parallel of latitude, under the influence of a more genial climate and better treatment, he is large, lively, and docile. The horse, originally a native of the central parts of the old continent, is now spread from the confines of the Arctic Circle to beyond the 50th degree of south latitude. It exists as high as Norway and Iceland, where it is small and of a peculiar variety, and extends even into the desolate regions of Patagonia. This animal was introduced into South America by the Spaniards, in their early visits to that continent; it has since greatly multiplied, and immense herds now rove wild over the *llanos*. The existence of these creatures is exposed to the most severe sufferings. " In the rainy season," says M. Humboldt, " the horses that wander in the savannah, and have not time to reach the rising grounds of the llanos, perish by hundreds amidst the overflowings of the rivers. The mares are seen, followed by their colts, swimming, during a part of the day, to feed upon the grass, the tops of which alone wave above the waters. In this state they are pursued by the crocodiles; and it is by no means uncommon to find the prints of the teeth of these carnivorous reptiles on their thighs.

" We cannot reflect," he proceeds, " on the effects of these inundations, without admiring the prodigious pliability of the organisation of the animals that man has subjected to his sway. In Greenland, the dog eats the refuse of the fisheries; and, when fish are wanting, feeds on sea-weed. The ass and the horse, originally natives of the cold and barren plains of Upper Asia, follow man to the New World, return to the savage state, and lead a restless and painful life in the burning climate of the tropics. Pressed, alternately, by excess of drought and of humidity, they sometimes seek a pool in the midst of a bare and dusty soil, to quench their thirst; and at other times flee from water, and the overflowing rivers, as menaced by an enemy that encounters them on every side. Harassed during the day by gadflies and mosquitoes, the horses, mules, and cows find themselves attacked at night by enormous bats*, that fasten on their backs, and cause wounds which become dangerous because they are filled with acaridæ, and other hurtful insects. In the time of great drought, the mules gnaw even the thorny melocactus (melon-thistle), in order to drink its cooling juice; and draw it forth as from a vegetable fountain. During the great inundations, these same animals lead an amphibious life, surrounded by crocodiles, water-serpents, and manatees. Yet, such are the immutable laws of Nature, their races are preserved in the struggle with the elements, and amid so many sufferings and dangers. When the waters retire, and the rivers return into their beds, the savannah is spread over with a fine odoriferous grass; and the animals of old Europe and Upper Asia seem to enjoy, as in their native climate, the renewed vegetation of spring."

It has been observed by Buffon, that the largest quadrupeds, such as the elephant, the rhinoceros, the hippopotamus, the camelopard, the camel, and most of the ox kind, are possessed exclusively by the old world. In America, the *fossil* remains of some large animals have been discovered; but of living species, there are very few of considerable bulk. It has also been remarked, that the tribes which are the most powerful and perfect in their structure belong chiefly to the old world; those of the new having, in general, a character of organisation which assigns them a lower rank in the scale of animated beings. Such carnivorous animals, for example, as have the greatest vigour and courage (among which are the lion, the tiger, and the hyæna) are confined to Asia and Africa. The American tribes which approach most nearly to these, are, in general, much more gentle and feeble than the African and Asiatic species. It must be admitted, however, that Buffon's assertion respecting the cowardice of the feline race of America must be taken with some limitation: for it appears that the jaguar will sometimes attack men; and, when assailed by armed numbers, he has been known to offer an obstinate resistance. The swiftest, as well as the most graceful and beautiful quadrupeds (the antelopes, for example) also chiefly belong to the old continent; while those kinds which are the most useful to man, including the goat, the horse, the ox, and the ass, were unknown in America till their introduction into that country by the Spaniards.

---

* In Brazil, in the province of Ciara, the bats cause such destruction among the cows, that rich farmers are said from this cause to be sometimes reduced to indigence.

Confining our view to wild animals, we may divide the earth into a number of zoological regions or provinces, each of which is the residence of a distinct set of quadrupeds*.

The first of these provinces, if we commence from the north, is the Arctic region, which contains the white bear, the rein-deer, the Arctic fox, and other tribes common to both of the great continents. The circumstance of their being common to both continents, is accounted for by the communication which, during winter, is established between the shores of Asia and America by means of the ice, over which a passage from one to the other becomes practicable to such animals as are fitted to endure the intense cold of the circumpolar countries.

The northern temperate zone is divided by the ocean into two great districts. The same tribes are found to be spread from the western to the eastern parts of the old continent; but the quadrupeds which inhabit the temperate climate of America are peculiar races.

The equatorial region contains three extensive tracts, widely separated from each other by the sea. These are the intertropical parts of Africa—of America—and of continental India. Each of the three tracts in question has a distinct nation of quadrupeds. The Indian isles, particularly the Sunda and Molucca islands, may also be considered as a separate region.

Beyond the Indian Archipelago is Papua, under which name it is usual to include New Guinea, New Britain, and New Ireland. These countries, with the islands which are formed by a continuation of their mountain chains, namely, the archipelago of Solomon's Islands, Louisiade, and the New Hebrides, together with the more remote groups in the great Southern ocean, may be regarded as one zoological province. It is remarked, that all this extensive region seems almost wholly destitute of native warm-blooded quadrupeds, except a few species of bats, and some small domestic animals in the possession of the natives.

The large region of Australia forms another zoological province, in which are contained many indigenous tribes of a very singular description; and, lastly, the southern extremities of America and Africa are each distinguished by the possession of peculiar races.

Of these several provinces, into which the animal world admits of division, none is peopled with so remarkable a stock of animals as Australia, including, under that designation, New Holland, and the adjacent islands to the southward. It possesses several entire genera of quadrupeds which have been discovered in no other part of the world; and it further deserves notice, that most of the tribes peculiar to New Holland, though on the whole very different from each other, have some striking characters of organisation common to all. It was assumed by Linnæus, that the great class of warm-blooded quadrupeds was, without exception, *viviparous* and *mammiferous*—two terms, the first of which denotes their production of their offspring in a living and perfect state; and the second, their being supplied with organs for suckling their young. On this latter account, it received the name of *mammalia*, by which it is known among naturalists. It appears, however, that, in New Holland, a tribe of warm-blooded animals has been discovered, to which that name is not applicable, because it is *oviparous* (that is, produces *eggs*), and is therefore unprovided with organs of the description above-mentioned. This curious tribe is, as far as our present knowledge extends, quite confined to New Holland. Another remarkable tribe is the *marsupial*, which term comprises such as produce their young in an immature state, and keep them for a time attached to their bodies, chiefly in abdominal *bags* or *pouches*, given them by nature for that purpose. This tribe also is met with principally in New Holland. One genus of it, indeed, the opossum or didelphis, is peculiar to the warm parts of America, and some species of phalangers are seen in the Moluccas; but over the Australian regions there are distributed several genera of the marsupial order, comprehending more than 40 species. Among these are the wombat, the kangaroo-rat, the kangaroos, and the dasyuri or Australian opossums.

---

* See Dr. Prichard's work, before mentioned.

The didelphis, or American opossum, differs from the Australian opossum in several respects; one of which is the having a long prehensile or muscular tail, which serves as a fifth limb, and is of great use to animals which inhabit forests so extensive and lofty as those of Guyana*. In the same part of America there are other animals which resemble the opossum in this respect; these are the sapajous, a numerous tribe of monkeys, the ant-eaters, the kinkajou, and the hystrix prehensilis (prehensile porcupine). Herein we behold striking instances of the structure of animals being fitted to the nature of the country in which they reside. The monkeys of Africa and of India are distinguished by no such peculiarity, for in those parts of the world it is not requisite.

We have already mentioned that the new continent is, compared with the old, nearly destitute of the most powerful and perfect tribes of quadrupeds. In their place are found most of those singular races, in the formation of which the ordinary rules of nature seem most widely to have been relinquished. Such are the tribes which Cuvier has termed Edentes, or quadrupeds defective with respect to teeth, some of them being entirely destitute of those organs. Thus America contains the whole family of sloths, the ant-eaters, which are quite unprovided with teeth, and the armadilloes, which have grinding teeth, but no tusks or cutting teeth.

That part of Southern Africa which extends beyond the tropic of Capricorn, forms quite a distinct zoological province, separated as it is by the intervention of the torrid zone, from the milder climates north of the equator. Accordingly the animal creation of this region assumes a character almost as peculiar as that which is displayed by its vegetation. Of the order termed Mammalia, Southern Africa contains several peculiar genera, which occupy various distances towards the north, according to the degree in which they are capable of enduring a hot climate. In many instances the same *genera* are found in this region as in temperate countries north of the equator; but it is particularly to be observed, that the southern *species* differ from the northern. Thus the quagga, the zebra, and some others of the horse kind, answer to the ass and the jiggetai of Asia. From the southern tropic to the Cape of Good Hope, the continent of Africa stretches into fine level plains, over which roam a great diversity of hoofed quadrupeds. Besides five of the horse genus, there are also peculiar species of rhinoceros, of the hog and the hyrax; and among ruminating animals, the giraffe or camelopard, the Cape buffalo, and several remarkable antelopes, as the spring-bock, the gnou, the leucophoe, and others.

The animals of the Indian Archipelago have in some respects a different character from those of continental India, and approach towards those of Africa. The Sunda isles are said to contain a hippopotamus —an animal which does not exist in the rivers of Asia. The rhinoceros of Sumatra resembles the African more than the Indian species, but is specifically different from both. It is the same with the crocodile tribe, which is divided into three sub-genera, the crocodile proper, the alligator or cayman, and the gavial. The alligator belongs to America—the gavial inhabits the Ganges, and probably other rivers in continental India—of the crocodile proper there are six species, of which some belong to Africa, others to the isles of the Indian ocean, and one is said to have been discovered in the West Indies. Among flying quadrupeds, the flying macauco or lemur, is seen only in the islands of the Indian ocean; two species of flying squirrel, and two remarkable genera of the family of bats, also reside there; besides which some of the flying phalangers are supposed to belong to the Moluccas.

It will be proper, in the next place, to inquire more particularly into the manner in which the most numerous families of quadrupeds are distributed over different parts of the world. In this enumeration, it is of course not intended to include those animals which man has been the means of conveying from one country to another, whence the same species have in some instances become scattered over the most distant parts of the earth.

---

* The phalangers of Australia and the Moluccas have the prehensile tail.

Most of those animals which Linnæus comprised in his order *Primates*, inhabit warm or temperate climates. The two grand divisions of this order are the bat and the monkey tribes. The latter has been subdivided by Cuvier into two chief branches, very different from each other—the simiæ proper, which are confined to the old continent—and the sapajous, which are peculiar to America. The African simiæ are distinguished from the Indian; and most of their species are limited each to a comparatively small tract. In the island of Madagascar, no true simiæ exist, but in their place are the makis, a tribe of lemurs. Of the bat tribe, the rousettes or frugivorous (*fruit-eating*) bats, inhabit the Indian archipelago and Australia, and the vampyres, or blood-sucking bats, nine species of which have been mentioned, are all peculiar to the hot parts of America. The most numerous genus of bats are the vespertiliones; some of these are very extensively dispersed, but this is not the case with the majority, and not one species is common to the old and new Continents.

The *feræ*, or carnivorous quadrupeds properly so termed, are extensively spread, although most of them belong to hot climates. Of the twenty-eight species of the cat kind, which have been enumerated, not one is the same in America and in the Old Continent; even the lynx of Canada is now believed to be a distinct kind from the European. The African species are generally confined to Africa, and the Indian to the eastern side of the Indus. The tiger is found only in Asia, extending as high as Chinese Tartary; but it is by far most common in India, living in ravines and jungles. Africa, although destitute of tigers, possesses panthers and leopards. The lion is most formidable in Africa, where there are two species, the Barbary and the Senegal; it is also said to belong to India, and it inhabits those parts of Arabia and Persia, which border on the Tigris and Euphrates from the Persian Gulf as far as Bagdad. The Arabian species is smaller than the others, and the males have no mane. The *couguar* or *puma*, a native of South and North America, which is sometimes called the American lion, is a very different animal from the real lion. Of the dog kind, several species endure an arctic climate, and are common to the high latitudes of both continents. The *lagopus* or *isatis* (arctic fox) is found at Spitzbergen, and may be traced through the north of Asia to Kamtchatka, and thence to the shores of America, Hudson's Bay, and Greenland. The wolf and the *lycaon* (black fox) are also common to all the arctic countries. Others of the dog-kind require a warm or a temperate climate, and these occupy a limited space either in Asia, in Africa, or in America. The dog of the Falkland islands (*canis antarcticus*), which was the only quadruped discovered there, has by some been considered a separate species, while others have held it to be the same as a species which inhabits Chili.

The *pachydermatous* (thick-skinned) tribes, live only in warm or temperate regions. There exist two species of elephant, the Indian and the African. Of the rhinoceros there are several species, but none of them are possessed in common by Asia and Africa. Those with two horns inhabit southern Africa, those with one horn belong to India and China, and to some of the islands of the Indian Archipelago. In America, the only representative of these large pachydermatous animals is the tapir. The hyrax and the hog tribes do not extend into cold climates; the wild boar, which ranges further towards the north than any of his tribe, is spread over various parts of Europe, but is never seen to the north of the Baltic. The domestic hog, since its introduction into America, has run wild and formed large herds in that Continent.

Among ruminating animals, the goat, the antelope *, and the giraffe, or camelopard, are limited to the Old Continent; but of sheep, some peculiar species are possessed by America, as, for instance, the paco, which in its domestic state is called bicunua or vigonia, and is an inhabitant of Peru. The camelopard, which is so remarkable for its height, its swan-like neck, and its gentle disposition, is a native of southern Africa. The antelope, of which the species are very numerous, is almost confined to Asia and Africa, none of them being found in Europe, except the chamois and the saiga. They inhabit as well the torrid zone as those parts of the temperate zones which are not very remote from the tropics. The dromedary, or camel with one hump, is a native both of Africa and Asia; the two-humped or Bactrian camel, so called because it is supposed to have originally come from Bactriana, belongs to much more northern climates than the other: it lives in the Crimea and in central Asia, in countries where the winter is very severe. The llama, or guanaco, which has been named by some the camel of the New World, is a widely different kind from either of the preceding. The musk resides in the mountains of Asia, from Cashmere, along the Altaï, to the mouth of the river Ameer. This animal is not seen in the New Continent, although there are tribes which bear a relation to it. Some species of the deer and ox inhabit very cold climates, and these have passed along the arctic regions from one continent to the other. Those which are unable to support such severe seasons, are confined to certain local tracts in either continent.

---

* Several American species have been described which are considered to be nearly related to the antelope.

We shall conclude our inquiry into the distribution of quadrupeds, with the mention of some facts respecting the description of animals discovered in islands. Small islands lying at a great distance from continents are in general quite destitute of land quadrupeds, except such as appear to have been conveyed to them by men. Kerguelen's Land, the islands of Juan Fernandez, the Gallapagos, &c., are instances of this fact. Among all the fertile groups in the Pacific Ocean, dogs, rats, hogs, and a few bats, are the only quadrupeds which have been seen. The Indian isles near New Guinea, abound in oxen, buffaloes, goats, deer, cats, rats, hogs, and dogs; but, according to all accounts, none of these have reached New Guinea, the two latter excepted. In Easter island, the most remotely seated in the Pacific, there are no domestic animals, except fowls and rats, which are eaten by the natives.

The quadrupeds of islands situated in the neighbourhood of continents, are generally the same as those of the adjacent main-land. This remark may be made respecting the animals of the British and of the Mediterranean isles, as well as of those in Madagascar, and in the islands near New Holland. When in such islands any quadrupeds are met with, which do not exist in the neighbouring continents, they are usually distinct species which occur no where else, and either have always had a local existence, or have been entirely destroyed from the main-land.

There is thus reason to conclude, that islands in general derived their quadrupeds from the continents in the neighbourhood of which they are placed.

Having now stated the facts which relate to the distribution of the principal races of animals, it remains only to inquire what inference we are entitled to draw concerning the manner of their original dispersion over the earth: whether that dispersion took place from a single spot, or whether, as in the case of the vegetable tribes, it commenced from a variety of distinct centres.

The local existence of insects is so closely connected with that of the plants which not only yield them sustenance, but also, in many instances, furnish their only place of abode, that we might at once expect to find the same laws prevailing in the dispersion of this part of the animal creation, as in that of the vegetable tribes. This conjecture has been confirmed by positive researches. M. Latreille, by whom the subject has undergone a full investigation, states, that the whole or the greater part of the arachnides and insects which inhabit countries of similar soil and temperature, but widely distant from each other, consist in general of different kinds. All the insects and arachnides which have been brought from the eastern parts of Asia, under whatever latitude, are distinct from those of Europe and of Africa. It further appears, that with insects, as with plants, where the species are different, the *genera* are nevertheless often the same. In this manner, the entomology of America approximates to that of the Austral countries, and the east of Asia. The insects of New Holland are often of the same genera with those of the Moluccas, and the south-eastern parts of India; they show much affinity to those of New Zealand and New Caledonia, and, as just observed, include similar genera to those of America: yet the entomology of New Holland is, notwithstanding, marked by a peculiar character. A large number of insects are found near the Cape of Good Hope, which are unknown in other countries: M. Lichtenstein collected there between 600 and 700 species, of which 340 were ascertained to be entirely new.

In adverting to the dispersion of the various tribes which inhabit the waters of the ocean, including the marine mammalia, as well as fishes and molluscæ, it is to be remarked that, in the descriptions of these tribes, great vagueness and inaccuracy has long prevailed. Therefore it is that this department of the animal kingdom contains so many species which are said to inhabit indiscriminately all parts of the ocean. The common whale (*balæna mysticetus*) has been supposed to belong equally to the frozen seas of Spitzbergen and to those of the antarctic circle. The sea-calf (*phoca vitulina*) is reported by several writers to be a native not only of both circumpolar regions, but also of the seas of the torrid zone; while some have gone so far as to assert that it exists in the Caspian, and even in the fresh-water lakes of Baikal, Onega, and Ladoga. But the fact of such extensive dispersion of marine animals rests entirely on the authority of incompetent persons. The celebrated naturalists Lesueur and Péron, who personally collected and examined a vast number of marine species in the southern hemisphere, have come to the conclusion, that the arctic ocean does not contain one tribe, well known and described, which is not *specifically distinct* from those animals most analogous to it in the antarctic seas. This remark applies not only to the cetaceous and phocaceous tribes, but also to the lower departments of marine animals; and, descending through a variety of worms and molluscæ, even to the shapeless sponges of the antarctic waters, these naturalists assert that, among all this immense assemblage, not one species will be found which exists in the seas of the northern hemisphere. It further appears that those maritime animals, which possess little power of self-extension, prevail within very narrow limits. Each species of the family of *medusæ* is seen in abundance in particular districts, and occurs in no other place. It is the same with the numerous *testacea* which adorn the shores of the southern seas. The shores of Timor present a great multitude and variety of beautiful testacea; but not one of these extends so far as the southern coast of New Holland.

With respect to reptiles, birds, and quadrupeds, the facts already stated concerning their distribution are sufficient to show that different regions of the world are each in possession of peculiar kinds. Many entire genera are wholly confined to certain districts; but when, as it frequently happens, the same genus is discovered among the wild and native animals of two distant regions, to a communication between which natural obstacles are opposed, it is not the same *species* that inhabit both countries, but corresponding species of the same *genus*. Thus the American species of the cat kind differ from the African and the Asiatic; and the species of horse, ox, antelope, rhinoceros, and elephant, of Africa, are distinct from those of the same genera in Asia.

Under these circumstances, we can arrive at no other conclusion than that the first dispersion of animals, like that of vegetables, took place from divers points. It is probable that, at least, each of the great mountainous chains and table lands was originally furnished by the Creator with a stock of animals. The offspring of each species have since spread themselves to as remote a distance from the first spot of their existence as their locomotive powers, their capability of bearing changes of climate, or the absence of physical obstacles to their further progress, may have allowed them to wander.

On Man in his Physical Character—His universal Dispersion over the Earth—Unity of his Species—Terms Genus and Species explained—Varieties of the Human Race, and manner in which they may be accounted for—Influence of Climate.

THE physical character of man, although it be not such as to exempt its possessor from those laws of generation, of growth, and of dissolution, which prevail among the inferior tribes of animals, is nevertheless of a peculiar and pre-eminent kind. His organisation, more perfect and complex than theirs; his erect and noble aspect; his form, better suited for rendering obedience to the impulses of a rational and intelligent mind;—all essentially distinguish him from the brutes over whom he exercises dominion. Under such circumstances as these, it is not a little surprising that there should ever have existed naturalists who pretended to confound the human species with tribes of the lower animal creation.

In some respects it may appear that the organisation of man subjects him to great disadvantages: the extreme feebleness of the human frame at the first period of its existence; the slowness of its growth; the multiplicity of its wants; the variety of ills and infirmities to which through life it is exposed, have no parallel among the beasts of the field. Yet who that considers the present moral imperfection of man, can deny the good which results from these physical disadvantages inseparable from his condition? Endued with the strength of the lion or the elephant, or clothed with a skin impervious to cold and moisture, he would probably have remained sunk in selfish indolence, and ignorant of all the arts which embellish life. But the feeling of his wants and weakness has aroused faculties which would else have lain dormant in his mind—has, by uniting him to his fellows, given rise to the most endearing ties and the most useful forms of society; and has so called forth his inventive resources, that he has, to a considerable extent, acquired the command and the direction of the powers of nature.

The researches of modern navigators have shown that the human race is spread nearly over the whole earth. It has been found in the midst of the most sultry regions, in the vicinity of the pole, and upon islands which a boundless ocean would have seemed to cut off from communication with the rest of the world. The islands of Spitzbergen and of Nova Zembla to the *north*, and Sandwich Isle, the Isles of Falkland, and Kerguelen's Land to the *south*, are the only countries of considerable extent which have been found entirely destitute of human inhabitants. In the north, the habitations of man stretch nearly to the 75th degree of latitude; while in the south a miserable race (that of the Petcheres) exists on the bleak and barren shores of Terra del Fuego. The oases, or islands of verdure, scattered over the sands of Africa, are also the seats of population. In one part of the world the human body supports a heat higher than that which makes ether boil; and, in another, a cold which occasions the congelation of mercury.

Notwithstanding the dissimilarities of structure and complexion which are observed upon comparing the natives of different countries, there are the strongest reasons to believe that the human race forms not only a single *genus*, but also a single *species*; or, in other words, that all the several varieties of men sprung originally from one pair of individuals. Though there exist independent grounds for this opinion (as will presently be shown), it is proper, before we proceed to a statement of these, to remark that the whole tenor of Revelation is against any other supposition.

We may discern in the difference between the means adopted for peopling the earth with the human race, and those provided for covering it with the inferior creatures, the traces of that wisdom which uniformly pervades the arrangements of Providence. Had there been, in the first instance, no more than one pair of each genus of animals, and one individual of each tribe of plants, and had these been called into being upon only one spot of the earth, large regions separated by wide seas and lofty chains of mountains from the country containing that single spot, would for ever have remained almost, if not entirely, destitute of plants and animals, unless at the same time means had been provided for their dispersion far more effectual than any which we behold in operation. To prevent a result so little in harmony with what appears to be the general system of the universe, each separate region of the globe was supplied with a distinct stock of plants and animals. But in the instance of the human race, such a plan of proceeding was not requisite. Man was endued with a constitution capable of accommodating itself to the greatest changes of climate, and with the power of inventing methods for protecting himself against atmospheric influence: he was also enabled, by the aid of the same power of invention, to transport himself over the most extensive seas and across the most formidable ranges of mountains. Furnished with these capabilities, his race was originally placed in only one spot of the world.

In order that the question may be fully understood, it is requisite to explain what is signified by the terms *genus* and *species*, of which frequent use has been made in the course of the present treatise. A race of animals, or a tribe of plants, marked by any peculiarities of structure, which from one generation to another have always been constant and undeviating, form a *species;* and two races are held to be *specifically distinct*, if they are distinguished from each other by some peculiarities, which, in the lapse of generations, the one cannot be supposed to have acquired, or the other to have lost, through any known operation of physical causes: so that, under the word species, are comprised all those animals which are concluded to have sprung, in the first instance, from a single pair*. The term *genus* has a more extensive application. There are several species which so resemble each other as immediately to suggest the idea of some near relation between them. The horse, the ass, the zebra, and others of the horse kind, are one instance of this remark; the different species of elephants are another; and a third is furnished by the several kinds of oxen, buffaloes, bisons, &c., all belonging to the ox genus, and bearing a striking resemblance one to the other. As no physical causes are known which could have operated so as to produce those differences of structure, which exist between the several species of one genus, it is concluded that they originally sprung from different individuals. A *genus*, consequently, is a collection of several species on a principle of resemblance; and it may, therefore, comprise a greater or less number of species, according to the particular views of the naturalist. It is not, however, always easy to determine what races of animals are of the same, and what of separate species. It is a well-known fact, that considerable varieties arise within the limits of one species; and such varieties are often transmitted to the offspring, and become, in a great measure, permanent or fixed in the race. Hence the difficulty, in some cases, of deciding whether two races of animals, of the same genus, and similar in many particulars, but differing in others, are merely what are termed *varieties* of one species, their diversities having proceeded from the action of external, or other causes, on a stock originally the same, or tribes of an entirely distinct origin from the beginning.

---

* It is certainly possible that what we term one species may have sprung from two or more original pairs *exactly alike;* but, judging from all that has been observed, it is by no means probable.

Dr. Prichard, in an able work entitled "Researches into the Physical History of Mankind," to which we have before had occasion to refer, mentions the criteria which may be used in order to determine whether all the races of men belong to the same species. The first of these is furnished by a reference to the general laws of their animal economy: since, should it appear that, in two races of animals, the duration of life is the same; that their natural functions observe the same laws; that they are subject to the same diseases, and susceptible of the same contagions—there is a very strong presumption that they are of the same species. Another way of examining the subject, is, to inquire whether the diversities in mankind are strictly analogous to those varieties in form, colour, &c., which occur in the lower departments of the animal creation, within the limits of the same species. The method, however, which bears most directly upon the question, is to ascertain what is positively known respecting the springing up of varieties among the human race.

First, with respect to the laws of the animal economy, it may be inquired whether there are any peculiarities which distinguish one race of men from another, of such a description as to render it probable that they constitute distinct species. Certain writers have supposed that there is a difference between Europeans and some other nations, in the duration of life. It is not to be denied that savage nations are, in general, shorter lived than the inhabitants of civilized countries; but this circumstance is sufficiently explained by their addiction to intemperate habits, and their constant exposure to fatigue and hardships. When they have not such disadvantages to contend with, their term of life seems to be as long as that of any other race of men. Several instances are cited, both of negroes in the West Indies, and of native Africans, having attained to a very advanced age; and among the natives of America, cases of longevity are far from uncommon. Humboldt mentions the name of a Peruvian who lived to the age of one hundred and forty-three, and who, only thirteen years before his death, was accustomed to travel on foot from three to four leagues daily. The Laplanders, again, are said to be rather remarkable for long life.

As to diseases, it seems an undoubted fact that all human contagions, and all epidemic complaints, exert their pernicious influence on every tribe of men, though the natives of particular climates suffer more than others. And as to constitutional complaints, the difference is only one of predisposition, and analogous to what is witnessed in different families in the same nation, some being constitutionally more liable to certain disorders than others. The constitution of the American is observed to be the most torpid, that of the European in general the most irritable.

The conclusion which results from the first method of inquiry, as will be more particularly seen by referring to the work above-mentioned, is, that the grand laws of the animal economy are the same in their operation upon all the races of mankind. The deviations which occur are not greater than the common varieties in constitution which exist within the limits of the same family. Here, then, is one strong presumption in favour of the inference that all men belong to one species; for it appears that, among animals, neighbouring species, so closely allied as to have often been taken for mere varieties of the same stock (as the wolf and the dog), differ materially in the laws of their animal functions.

The next mode of inquiry suggested, is, how far the diversities of complexion, figure, and stature, seen among the several races of men, are analogous to those varieties which, in the inferior animals, often occur without marking any specific difference, and, indeed, originate before our eyes within the limits of the same species. In this place we shall accordingly note the most remarkable instances of variety which appear in mankind.

One, and that the most obvious to common observers, is the *diversity of colour*. It is well known that there is a correspondence between the colours of the skin, the hair, and the eyes of individuals. With few exceptions, light-coloured eyes are joined to a fair complexion and light hair, but a relation of the colour of the skin to that of the hair is perhaps universal. The women of Barbary and Syria are said to be often very white, although they have black hair; but this is to be attributed to art, and careful protection from the sun. Dr. Prichard, taking the hue of the hair as the leading character, divides mankind into *three* principal varieties of colour, which he calls the *melanic*, the *xanthous*, and the *albino*. The first includes all individuals or races who have *black* hair; the second, those who have either brown, auburn, *yellow*, flaxen, or red hair; and the third, those who have *white* hair, and who are also distinguished by red eyes. "The *melanic* variety forms by far the most numerous class of mankind. It is the complexion generally prevalent; except in some particular countries, chiefly in the northern regions of Europe and Asia, where races of the xanthous variety have multiplied; and it may be looked upon as the natural and original complexion of the human species. The hair of the head, in the melanic races, is of various texture and growth, from the long and lank hair of the native Americans, to the fine crisp hair of the African negroes. The hue of the skin varies from a deep black, which is that of some African nations, to a much lighter or more dilute shade. The dusky hue is combined, in some nations, with a mixture of red, in others with a tinge of yellow. The former are the copper-coloured nations of America and Africa; the latter, the olive-coloured races of Asia. In the deepness or intensity of colour we find every shade or gradation, from the black of the Senegal negro, or the deep olive and almost jet black of the Malabars and some other nations of India, to the light olive of the northern Hindoos. From that we still trace every variety of shade among the Persians and other Asiatics, to the complexion of the swarthy Spaniards, or of European brunettes in general." Examples of the *albino* variety have been noticed in almost all countries. In Europe they are by no means uncommon; sixteen instances have been seen in Germany by Professor Blumenbach. The fact of their occurrence in other parts of the world is also fully established. It appears that they are frequent among the copper-coloured native Americans on the isthmus of Darien; and they have been observed in many islands both of the Indian and of the great Southern Ocean. Among the Hindoos they are regarded with peculiar horror. The most remarkable circumstance, yet not an unusual one, is the birth of white negroes among the black races of Africa: they are looked upon as curiosities, and are often collected by the native monarchs. Their hair is of a woolly character, and many of them are true *albinos*. The *xanthous* variety may be considered as intermediate between the other two. It chiefly prevails in the temperately cold regions of Europe and Asia, where it sometimes runs through whole tribes; but it also springs up out of every melanic race. The Jews, like the Arabs, are generally black haired, but many may be seen with light hair and eyes; and the same remark will apply to the Russians. The xanthous variety also appears among the South Sea islanders and the natives of America, and even among the negro races of Africa, both in their own climate and in the places to which they have been transported.

Varieties of form, more especially of the *shape of the skull*, furnish another grand instance of diversity among the races of men. The ingenious Professor Blumenbach has made the varieties in the construction of the skull the basis of a division of mankind into five principal races or departments, which he denominates, 1. the Caucasian; 2. the Mongolian; 3. the Ethiopian or Negro; 4. the American; and 5. the Malay and South Sea Island *. The *first* is that variety to which the nations of Europe and some of the western Asiatics belong; in this class the head is almost round, and of the most symmetrical shape, the cheek bones without any projection, the face oval, and the features moderately prominent. In the *second* class, the head is almost square, the cheek bones projecting *outwards*, the nose flat, the face broad and flattened, with the parts imperfectly distinguished, the internal angle of the eye depressed towards the nose. In the *third* class, the head is narrow and compressed at the sides, the forehead very convex, the cheek bones projecting *forwards*, the nostrils wide, the jaws lengthened, the skull in general thick and heavy, the face narrow, projecting towards the lower part, the nose spread and almost confounded with the cheeks, the lips, particularly the upper one, very thick. The *fourth* variety approaches to the Mongolian: the cheekbones are prominent, but more arched and rounded than in the skull of the Mongole, the form of the forehead and of the top of the head is often altered by means of artificial pressure during infancy, the face is broad without being flat, the forehead low, and the eyes deeply seated. In the *fifth* variety, the summit of the head is slightly narrowed, the forehead a little arched, the upper jaw somewhat projecting, the face less narrow, and the features more prominent and better marked than in the negro.

---

* The first three are the most strongly marked varieties in the form of the skull; the remaining two being only approximations to the preceding.

These descriptions give a clear idea of five principal varieties in the form of the human head; nevertheless, the attempt to assign them as the distinctive characters of so many races of men is open to strong objections; since, whether we take as a standard the figure of the skull, or perhaps any other peculiarity of structure, it is impossible, with reference to that standard, to divide the human species into departments, such as can be regarded with probability as so many separate races or families. The third, or Ethiopian variety of skull, is found in the greatest degree among the tribes inhabiting the coast of Guinea and other western countries of Africa; but it must not be set down as common among all the Negro nations; for there are many black and woolly headed races in Africa which come under the designation of Negro, who display a very different shape of the head and features from that described under the *third* variety. Again, the skulls of the New Hollanders are almost as much compressed as those of any Negroes, and they would, under the preceding classification, be brought within the Ethiopic race; yet no one could assert that the New Hollanders and the woolly-headed Africans, differing so much in other physical characters, and separated by so vast a distance, should be included in the same department of the human species. On this account, Dr. Prichard has proposed a division of the varieties of the skull into three classes, distinguished by names derived from their forms, and not from any supposed origin of the nations to which they respectively belong.

In the *shape of the body*, as well as in the *size and proportion of the limbs*, and consequently in the degree of strength and agility which they possess, there are some remarkable varieties among nations. Some Negro tribes, the Australian or New Holland savages, and the Kalmucks, seem to be those which differ most in figure from Europeans. According to numerous measurements, the arm below the elbow is somewhat longer in the Negro, in proportion to the upper arm, and to the height of the stature, than it is in the European. It has therefore been remarked, that in this respect the generality of Negroes approach more to the structure of the ape; but if we descend to individuals, many Europeans will be found in whom the fore arm is as long as in the majority of Negroes, and, on the other hand, Negroes in whom it is as short as in the majority of Europeans. A clumsy form of the legs, broad and flat feet, and large hands, are also described as peculiarities of the Negro.

With respect to *stature*, the difference between one nation and another is generally not very considerable. From all accounts, the tallest race of men existing are the Patagonians. They are usually more than six, and, in some instances, as much as seven feet in height. On the contrary, the natives of Tierra del Fuego are described as miserable and puny savages. The Esquimaux, in the north of America, are likewise diminutive, being generally under five feet. Africa also contains some small races. Of the Bosjesmans or Bushmen, who are said to be the most deformed of mankind, Lichtenstein saw two individuals who were scarcely four feet high. This unhappy race, who were plundered of their property and hunted down like wild beasts by the early settlers in the Cape colony, have since lived among the rocks and woods on the northern frontier of the settlement, where they support themselves in a great measure by depredation. These instances tend to show that when whole races are deformed and stunted, it is to be attributed to exposure to constant hardships or an inclement climate, and to the wretched and precarious nature of their subsistence. Both extremes of stature which have been observed among nations, are frequently surpassed by individual examples in the inhabitants of different countries. Many natives of Europe, from eight to nine feet high, have been exhibited as objects of curiosity, and there have been dwarfs of less than four, and even three feet.

The only other varieties in the human

race which require notice, are those in the *texture of the skin*, and *the character of the hair*. The skin of Negroes is said to be always cooler than that of Europeans in the same climate, and to be distinguished for its sleekness and velvet-like softness. A similar observation has been made of several African tribes, and also of the Otaheitans. These qualities of the skin seem to be connected with the existence of the dark matter by which, among these nations, it is coloured; for in *albinos*, both African and Otaheitan, the skin becomes rough and inflamed, and cracks upon being exposed to the sun. The contrasts between the hair of different races are exceedingly striking. In the Negro, the Hottentot, and some other races, the hair is short and crisp, somewhat approaching to the nature of wool; in other nations it is long and lank; and between these two kinds there are numerous gradations. In Africa, the Kaffers have hair like that of the Negroes; some tribes have it longer; some again, who are black and otherwise similar to Negroes, have hair curled, but not crisp. The Papuas (the name by which the inhabitants of New Guinea and the neighbouring islands are distinguished) have crisp hair; but, unlike that of the Africans, it grows very long, and admits of being spread out into an immense bush. The hair of the natives of Van Diemen's Land is as crisp as that of the Africans, but the New Hollanders have straight hair; while in the New Hebrides it is of an intermediate character, and varies considerably in the men of the same island. The hair of the natives of America is generally lank; in a few instances curled; but in none crisp or woolly.

In the next place, we shall compare the diversities, of which a sketch has been given, as existing in the appearance of the human race, with the variations in form, colour, and structure, which are seen in the lower animals, and especially in the domesticated kinds. The differences in colour which quadrupeds of the same species exhibit, are so familiar to the eye, that it is unnecessary to do more than allude to them. Among horses, oxen, dogs, cats, rabbits, &c., we continually behold hues which are analogous either to the melanic, the xanthous, or the albino varieties in mankind. Among several kinds of wild animals, a white not unfrequently springs up. In many instances, certain colours are prevalent in particular breeds, and in some cases we might be warranted in concluding that the colours depend upon the local circumstances of the countries in which the breed is placed. Blumenbach mentions several examples which will illustrate this remark. He states that all the swine of Piedmont are black; those of Normandy, white; and those of Bavaria of a reddish brown colour. In Hungary, the oxen are of a greyish white; in Franconia, they are red. The turkeys of Normandy are black; those of Hanover almost all white. In Guinea, the dogs and the gallinaceous* fowls are as black as the human race. Even in our own country, certain colours may be seen prevailing in the cattle of particular districts. Doctor F. Buchanan says, that in Mysore the sheep exhibit three sorts of colour: red, black, and white, and these are not distinct breeds. Don Felix de Azzara relates some curious circumstances respecting the colour of the horses and oxen in Paraguay, where, as well as in other parts of South America, both these races have run wild, and become very numerous. He says that all the *wild* horses are of one colour (a chestnut or bay-brown), whereas the domestic horses are of all colours, as in other countries. He makes a similar kind of observation concerning the oxen. As to form and the structure and proportion of parts, the diversities which arise in the same race of animals, far surpass those which subsist between one nation and another among men. Alluding to the hog tribe, Professor Blumenbach remarks, that "no naturalist has carried his scepticism so far as to doubt the descent of the domestic swine from the wild boar. It is certain that, before the discovery of America by the Spaniards, swine were unknown in that quarter of the world, and that they were first carried thither from Europe. Yet, notwithstanding the comparative shortness of the interval, they have in that country degenerated into breeds wonderfully different from each other, and from the original stock. These instances of diversity, and those of the hog kind in general, may therefore be taken as clear and safe examples of the variations which may be expected to arise in the descendants of one stock." He afterwards observes that the difference between the craniums of the Negro and of the European is not greater than that between the craniums of the wild boar and of the domestic swine. In the breeds of oxen, sheep, and horses, we may discern additional examples of deviation from an original standard. Some breeds of sheep and oxen are destitute of horns; others, on the contrary, are distinguished by the large size of their horns. In Paraguay there are breeds of oxen without horns, descended from the common horned race. With respect to horses, Blumenbach again observes that there is less difference in the form of the skull in the most dissimilar of mankind, than between the elongated head of the Neapolitan horse and the skull of the Hungarian breed, which is remarkable for its shortness and the extent of the lower jaw. The varieties in the covering of animals are not less worthy of notice than those to which reference has already been made. In the same race of sheep, some are clothed with wool, others with hair. It is known that if a flock is neglected, the fine wool is succeeded by a much coarser growth, intermixed with strong hairs; the breed, being no longer kept up with care, seems gradually to degenerate towards the characters of the *argali*, or wild sheep of Siberia, which naturalists consider to be the stock whence all domestic sheep have proceeded. A striking specimen of the changes which occur in breeds is afforded by the sheep of the West India islands, which, although descended from the woolly sheep of Europe, are covered with course hair. The deterioration has usually been attributed to the heat of the climate; but it must also be referred to the circumstance of their breed having been neglected. Other animals, such as goats and dogs, display a similar variety in the nature of their covering.

---

* From *gallus*, a cock.

The preceding facts clearly prove that, in the lower animal creation, there spring up, *in the same species*, varieties of an analogous or similar kind to those which mark the different races of men. The existence of this analogy confirms still further the opinion expressed as to the unity of the human species. It now only remains to inquire whether it is absolutely known that varieties have arisen in a family or race of men similar to those diversities which distinguish one nation from another.

It is a well-attested fact that, among negroes and other dark-coloured tribes, individuals of the albino and xanthous complexions are not unfrequently born; and with respect to form and structure, and the texture of the skin and hair, many instances are recorded wherein surprising peculiarities have made their appearance in a race or family, and some in which these have been transmitted to descendants. The description of such cases would exceed the limits of the present treatise; but an account of several may be seen by referring to the author* whom we already cited.

It appears, therefore, that if we apply to the subject under discussion the several criteria stated at the outset of this inquiry, the results, every one, lead to the inference that the various nations of the globe are descended from the same stock. This inference is drawn, *first*, from the observed uniformity in the grand laws of their animal economy, allowance, of course, being made for the effects of climate and of particular habits; *secondly*, from the existence in the same species among the inferior tribes of the creation, of varieties analogous to those which occur in mankind; and *thirdly*, from the fact of varieties being really known to have sprung up among men, more or less similar to those which distinguish different nations. There is, nevertheless, a point at which the similarity between the two cases obviously terminates: the peculiarities which arose in the human species at a remote and unknown period have become the characteristic marks of large nations, whereas those which have made their appearance in later times, have, in general, extended very little beyond the individuals in whom they first showed themselves, and certainly have never attained to anything like a prevalence throughout whole communities. But this is a circumstance which it does not seem difficult to explain, if we consider that, ever since the population of the world has been of large amount, the possessors of any peculiar organisation have borne such a very small numerical proportion to the nation to which they belonged, that it is no way surprising that they should soon have been lost in the general mass, still less that they should have failed to impress it with their own peculiar characters. In the early period of the world, when mankind, few in numbers, were beginning to disperse themselves in detached bodies over the face of the earth, the case was altogether different, and we can easily understand how, if any varieties of colour, form, or structure, then originated in the human race, they would naturally, as society multiplied, become the characteristics of a whole nation. These considerations may suggest to us the *manner* in which national diversities first obtained their ascendancy. The *causes* of those diversities are, and probably ever will remain, enveloped in mystery; and the inference as to the unity of the human kind is not weakened by our inability to assign those causes, since we are ignorant of the occasions even of the varieties which sometimes display themselves within the limits of a single family.

---

* Dr. Prichard's "Researches into the Physical History of Mankind."

It will be seen, however, upon a comprehensive survey, that in the distribution of the different races of men there is a certain relation to *climates*. We may observe that the *black* races of men are principally situated within the torrid zone; and the *white* races in the regions approaching towards the pole; and that the countries bordering on the torrid zone are generally inhabited by nations of a *middle* complexion. It further appears that the natives of mountainous and elevated tracts are usually of lighter colour than the natives of the low and hot plains on the sea-coast. In Africa, most of the races between the tropics are either black or of a very deep colour; while beyond the tropics the prevailing complexion is either brown or red. The people of Fezzan, who are of a black hue, form an exception to this rule; but it has been remarked of them, that they are chiefly slave-dealers, and have been intermixed with the negro race brought from the interior of Africa. In other countries of the globe, the majority of the nations near the equator are almost black. In India there are black tribes in Malabar; and the Hindoos of the Deccan are generally very dark, as are also the inhabitants of Ceylon. In most of the islands of the Indian ocean, the *aborigines* are of a black colour; and still further eastward are the Papuas of New Guinea and the black inhabitants of Solomon's islands and the New Hebrides. In equatorial America, the natives are not so dark as in other parts of the torrid zone; but its elevated mountains, vast rivers, and extensive forests, impart a peculiar character to the climate of the New World, which may probably account for the difference. In the low countries of California it is remarked that the population are nearly as dark as negroes.

It is a very general opinion, that the origin of the diversities of *colour* in mankind is to be referred entirely to the gradual influence of climate and of the sun's rays in darkening the complexion; it being a commonly-observed fact, that the skin, even of white men, becomes embrowned by constant exposure to the heat. But there are circumstances which militate against this opinion. There is positive testimony that the offspring of individuals, darkened by the sun in hot countries, is born with the *original complexion*, and not with the acquired hue of the parents*; besides which, it is known that white races of men, who have been removed from a cold to a hot climate, and have not intermarried with the natives, have retained for ages their original colour; while, on the other hand, black families, when transplanted into more temperate countries, have remained for generations of exactly the same hue as their African progenitors. Dr. Prichard has also remarked that the above supposition is contrary to a general law of the animal economy, according to which, *acquired* varieties† are not transmitted from parents to their offspring, but terminate in the generation in which they have had their origin.

Yet although it seems that the existence of varieties cannot be attributed to the slow and gradual operation of climate upon successive generations, numerous facts lead to the conclusion that there is a natural tendency among races, both of men and animals, to the production of varieties suited in form and constitution to the local circumstances of the country where they arise. Or it may, perhaps, be better explained, in some cases, by supposing that, whatever varieties occur, the ability to establish a footing in any country belongs to those only which possess a constitution adapted to local circumstances. Thus men of the *xanthous* variety of colour are known to spring up among the negroes in Africa; but their constitution being entirely unsuited to the climate, we cannot believe that they would ever become numerous in that continent. In the temperately-cold regions of the world they would be favourably circumstanced; and we accordingly see that this variety has multiplied there to a considerable extent.

---

* Dr. Prichard's "Researches," vol. ii. pp. 532, &c.

† *Acquired* varieties are opposed to those which a person brings into the world at his birth.

ADVERTISEMENT.

ROSE'S EDITION OF PARKHURST'S GREEK LEXICON.

In a very large volume, Royal 8vo. Price 1*l.* 11*s.* 6*d.* bds.

A GREEK and ENGLISH LEXICON to the NEW TESTAMENT; in which the Words and Phrases occurring in those Sacred Books are distinctly explained; and the Meanings assigned to each, authorised [illegible] References to Passages of Scripture; and frequently illustrated and confirmed by Citations from the Old Testament, and from the Greek Writers; with a Plain and Easy Greek Grammar, adapted to the use of Learners, and those who understand no other language than English. By JOHN PARKHURST, A.M.

A New Edition, comprising the more valuable parts of the Works of some later Writers. By HUGH JAMES ROSE, B.D. of Trinity College, Cambridge.

London: Printed for C. J. G. and F. Rivington; Longman, Rees, & Co.; T. Cadell; J. Richardson; R. Scholey; Baldwin & Cradock: Hurst, Chance, & Co.; Hamilton, Adams, & Co.; Whitaker, Treacher, and Arnot; Treuttel, Wurtz, and Co.; James Duncan; Simpkin & Marshall; J. Bohn; G. Wilson; James Nisbet; E. Hodgson; W. Mason; H. Steel; F. J. Mason; W. J. and J. Maynard; J. Wicksteed; Houlston and Son; Sterling & Kenny, Edinburgh; J. Parker, Oxford; and J. and J. J. Deighton, Cambridge.

*** In augmenting and correcting this Lexicon, the Editor has availed himself of the works of Schleusner, Bretschneider, and Wahl; and for improvements in the Grammar, those of Buttman and Matthiæ. The Additions to the former Edition of Parkhurst are at least one third of the whole.

EXERCISES TO TRANSLATE INTO LATIN.

The 11th Edition, thoroughly revised, Price 3*s.* 6*d.* bound.

A COLLECTION of ENGLISH EXERCISES, translated from the Writings of Cicero, for School Boys to re-translate into Latin, and adapted to the principal Rules in the Eton Syntax, with occasional References to other Grammars. By WILLIAM ELLIS, M.A.

London: Printed for J. G. and F. Rivington; Longman, Rees, Orme, Brown, and Green; J. Richardson; Baldwin and Cradock; Harvey and Darton; E. Williams; G. B. Whitaker & Co.; Harding & Co.; Hamilton, Adams, and Co.; and Simpkin and Marshall.

By whom also is Published,

A KEY to the Second and Third Parts, with References to the Passages in Cicero, Second Edition, Price 3*s.*

HANSARD'S PARLIAMENTARY DEBATES.

Just Published, Price 5*s.* Part I.—To be continued twice a-month.

THE PARLIAMENTARY DEBATES of the PRESENT SESSION.

London: Printed for Baldwin & Cradock; J. Booker; Longman, Rees & Co.; J. M. Richardson; Parbury, Allen & Co.; J. Hatchard & Son; J. Ridgway; E. Jeffery & Son; J. Rodwell; R. H. Evans; Calkin & Budd; J. Booth, and T. C. Hansard.—Where may be had all the preceding volumes.

WANOSTROCHT'S FRENCH GRAMMAR IMPROVED, BY JOSSE.

Just published, Price 4*s.* 6*d.* bound,

A GRAMMAR of the FRENCH LANGUAGE, with Practical Exercises. By N. WANOSTROCHT, LL.D. The Seventeenth Edition, Revised and Corrected by A. L. JOSSE, Author of a Grammaire Espagnole Raisonnée, the Tesoro Espanol, &c.

London: Printed for Boosey & Sons; J. Nunn; J. Richardson; Longman, Ree[illegible] Orme, Brown & Green; T. Cadell; Harv[illegible] & Darton; Baldwin & Cradock; Hard[illegible] and Lepard; J. Booker; Hamilton, A[illegible], and Co.; J. Duncan; Cowie and Co.; [illegible] Hunter; G. B. Whittaker & Co.; Dulau and Co.; Simpkin and Marshall; and Baker and Fletcher.

NEAT AND COMPENDIOUS FRENCH DICTIONARY.

In 12mo, Price 10*s.* 6*d.* bound, the Fifth Edition, carefully examined and Stereotyped,

A DICTIONARY of the FRENCH and ENGLISH LANGUAGES, in conformity with the French Academy: in two Parts, French and English, and English and French: in which are introduced many Thousand useful Words, not to be found in any other French and English Dictionary. With a copious Introduction on the Pronunciation of the French Language, and on the Varieties in the Declinable Parts of Speech. By M. DE LEVIZAC.

Thoroughly Revised, greatly Improved, and the two Parts most carefully Collated; with the Indication of the Irregularities of the French Pronunciation, by C. GROS, Author of a New Theoretical and Practical Grammar of the French Tongue, Elements of Conversation, Methodical Spelling, &c.

London: Printed for Baldwin and Cradock; Longman, Rees, and Co.; G. B. Whittaker & Co.; Dulau and Co.; E. Williams; and B. J. Holdsworth.

*** In the Compilation and subsequent improvement of this work, it has been the aim of both the Author and Editor to adapt it for the purposes of tuition, by the exclusion or modification of all words which are unfit to be presented to the eye of youthful readers.

Just Published, price 3*s.* bound,

A COMPLETE TREATISE on PRACTICAL ARITHMETIC and BOOK-KEEPING, both by Single and Double Entry, adapted to the Use of Schools. By CHARLES HUTTON, LL.D., F.R.S. Seventeenth Edition, enlarged and corrected: to which is added, an Appendix, containing a variety of Miscellaneous Questions for Examination. Also, the PRINCIPLES and PRACTICE of CIRCULATING DECIMALS; with their Application to the Computation of Interest, Rates for Interest on Accounts Current, &c. By OLINTHUS GREGORY, LL.D.

London: Printed for J. G. and F. Rivington; Longman, Rees, and Co.; Baldwin and Cradock; Harvey and Darton; R. Scholey; Boynes and Son; Hurst, Chance, and Co.; G. B. Whittaker and Co.; Hamilton, Adams, and Co.; J. Duncan; Simpkin and Marshall; T. and J. Allman; Wightman and Co.; and Baker and Fletcher.

By whom are also Published,

A KEY to the ARITHMETIC, price 4*s.* 6*d.*; and all the other Mathematical Works of Dr. Hutton.

HORSES & VETERINARY MEDICINE.

The Fifteenth Edition, illustrated by 23 Plates, 12mo. price 8*s.*

A COMPENDIUM of the VETERINARY ART, containing Plain and Concise Rules for the Treatment of all the Disorders and Accidents to which the Horse is liable; with Observations on Grooming, Feeding, Exercise, and the Construction of Stables. Also, a brief Description of the Structure, Economy, and Diseases of the Horse's Foot; with the Principles and Practice of Shoeing. By JAMES WHITE, late Veterinary Surgeon of the First or Royal Dragoons. Being the First Volume of his Treatise on Veterinary Medicine.

London: Printed for Longman and Co.; Baldwin and Cradock; J. Booker; T. Tegg; G. B. Whittaker and Co.; Simpkin and Marshall; Hurst, Chance and Co.; J. Duncan; and W. Joy.

By whom also are Published, of the same Author,—

Vol. 2, containing the Materia Medica and Pharmacopœia. Fifth Edition, price 6*s.*

Vol. 3, containing Observations on the Structure, Economy, and Diseases of the Digestive Organs of the Horse, and other Diseases resulting from them. With Practical Observations on the Treatment and Prevention of Lameness. Seventh Edition, price 6*s.*

Vol. 4. A COMPENDIUM of CATTLE MEDICINE; or, Practical Observations on the Disorders of Cattle and other Domestic Animals, except the Horse. With a Series of Essays on the Structure, Economy, and Diseases of Horned Cattle and Sheep, as communicated to the Bath and West England Society. Fifth Edition, price 6*s.*

DONN'S CATALOGUE OF PLANTS.

In 8vo. price 10*s.* 6*d.* the Eleventh Edition.

HORTUS CANTABRIGIENSIS; or, an Accented Catalogue of Indigenous and Exotic Plants cultivated in the Cambridge Botanic Garden. By the late JAMES DONN, Curator, F.L.S. &c. With numerous Corrections and Additions by JOHN LINDLEY, F.L.S. &c.

London: Printed for J. G. and F. Rivington; Longman, Rees, and Co.; T. Cadell; John Richardson, Baldwin and Cradock; Hamilton, Adams and Co.; E. Edwards; and G. B. Whittaker and Co.

In 2 vols. 8vo. with Plates, price 16*s.* a new Edition of

THE NATURAL HISTORY of SELBORNE. By the late Rev. GILBERT WHITE, M.A. Fellow of Oriel College, Oxford. To which are added, The Naturalist's Calendar, Miscellaneous Observations, and Poems.

London: Printed for S. and A. Arch; Longman and Co.; Baldwin and Cradock; J. Hatchard and Son; S. Bagster; Ogle, Duncan and Co.; W. Mason; J. Sheldon; and R. Saunders.

Just Published, Vols. XI. and XII. in 8vo. price 12*s.* each,

A HISTORY of ENGLAND, from the FIRST INVASION of the ROMANS. By JOHN LINGARD, D.D.

London: Printed for Baldwin and Cradock; and B. Fellowes, Successor to Mr. Mawman. Of whom may be had, the Seventh Volume of the Quarto Edition, bringing the History down to the Twenty-Seventh Year of the Reign of Charles II. Price 1*l.* 15*s.*

Also the Fourth Edition, Price 2*s.* 6*d.* of A VINDICATION of certain Passages in the Third and Fourth Volumes; with a Postscript in answer to Dr. Allen's Reply.

This Day is Published, Price 5*s.*

THE JURIST, No. V.

CONTENTS.—Art. I. Written and Unwritten Law; II. Administration of Justice in the East Indies; III. Cooper's Letters on the Court of Chancery; IV. Fees in Courts of inferior Jurisdiction in Scotland; V. Police of the Metropolis; VI. Present State of the Court of Chancery; VII. Dr. Reddie's Observations on Mr. Humphries's Reply; VIII. Statutes passed in the last Session of Parliament.

London: Printed for Baldwin and Cradock; by whom also are Published,

THE HISTORY of the CHURCH of ENGLAND. By J. B. S. CARWITHEN, B.D of St. Mary Hall, Oxford; Bampton Lecturer for 1809; and Vicar of Sandhurst, Berks.

Part the First—to the Restoration of the Church and Monarchy in 1660. In two large vols. 8vo. Price 26*s.*

NPLCO